Cell 1 Regional Coastal Monitoring Programme Analytical Report 9: 'Full Measures' Survey 2016

Hartlepool Borough Council

March 2017

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    1.

Abbreviations and Acronyms

Acronym / Abbreviation	Definition
AONB	Area of Outstanding Natural Beauty
DGM	Digital Ground Model
HAT	Highest Astronomical Tide
LAT	Lowest Astronomical Tide
MHWN	Mean High Water Neap
MHWS	Mean High Water Spring
MLWS	Mean Low Water Neap
MLWS	Mean Low Water Spring
m	metres
ODN	Ordnance Datum Newlyn

Water Levels Used in Interpretation of Changes

	Water Level (m AOD)			
Water Level Parameter	**River Tyne to Frenchman's Bay**	**Frenchman's Bay to Souter Point**	**Souter Point to Chourdon Point**	**Chourdon Point to Hartlepool Headland**
1 in 200 year	3.41	3.44	3.66	3.91
HAT	2.85	2.88	3.18	3.30
MHWS	2.15	2.18	2.48	2.70
MLWS	-2.15	-2.12	-1.92	-1.90
	Water Level (m AOD)			
Water Level Parameter	**Hartlepool Headland to Saltburn Scar**	**Skinningrove**	**Hummersea Scar to Sandsend Ness**	**Sandsend Ness to Saltwick Nab**
1 in 200 year	3.87	3.86	4.1	3.88
HAT	3.25	3.18	3.15	3.10
MHWS	2.65	2.68	2.65	2.60
MLWS	-1.95	-2.13	-2.15	-2.20

Source: *River Tyne to Flamborough Head Shoreline Management Plan 2*. Royal Haskoning, February 2007.

Glossary of Terms

Term	Definition
Beach nourishment	Artificial process of replenishing a beach with material from another source.
Berm crest	Ridge of sand or gravel deposited by wave action on the shore just above the normal high water mark.
Breaker zone	Area in the sea where the waves break.
Coastal squeeze	The reduction in habitat area which can arise if the natural landward migration of a habitat under sea level rise is prevented by the fixing of the high water mark, e.g. a sea wall.
Downdrift	Direction of alongshore movement of beach materials.
Ebb-tide	The falling tide, part of the tidal cycle between high water and the next low water.
Fetch	Length of water over which a given wind has blown that determines the size of the waves produced.
Flood-tide	Rising tide, part of the tidal cycle between low water and the next high water.
Foreshore	Zone between the high water and low water marks, also known as the intertidal zone.
Geomorphology	The branch of physical geography/geology which deals with the form of the Earth, the general configuration of its surface, the distribution of the land, water, etc.
Groyne	Shore protection structure built perpendicular to the shore; designed to trap sediment.
Mean High Water (MHW)	The average of all high waters observed over a sufficiently long period.
Mean Low Water (MLW)	The average of all low waters observed over a sufficiently long period.
Mean Sea Level (MSL)	Average height of the sea surface over a 19-year period.
Offshore zone	Extends from the low water mark to a water depth of about 15 m and is permanently covered with water.
Storm surge	A rise in the sea surface on an open coast, resulting from a storm.
Swell	Waves that have travelled out of the area in which they were generated.
Tidal prism	The volume of water within the estuary between the level of high and low tide, typically taken for mean spring tides.
Tide	Periodic rising and falling of large bodies of water resulting from the gravitational attraction of the moon and sun acting on the rotating earth.
Topography	Configuration of a surface including its relief and the position of its natural and man-made features.
Transgression	The landward movement of the shoreline in response to a rise in relative sea level.
Updrift	Direction opposite to the predominant movement of longshore transport.
Wave direction	Direction from which a wave approaches.
Wave refraction	Process by which the direction of approach of a wave changes as it moves into shallow water.

Preamble

The Cell 1 Regional Coastal Monitoring Programme covers approximately 300km of the north east coastline, from the Scottish Border (just south of St. Abb's Head) to Flamborough Head in East Yorkshire. This coastline is often referred to as 'Coastal Sediment Cell 1' in England and Wales (Figure 1). Within this frontage the coastal landforms vary considerably, comprising low-lying tidal flats with fringing salt marshes, hard rock cliffs that are mantled with glacial sediment to varying thicknesses, softer rock cliffs and extensive landslide complexes.

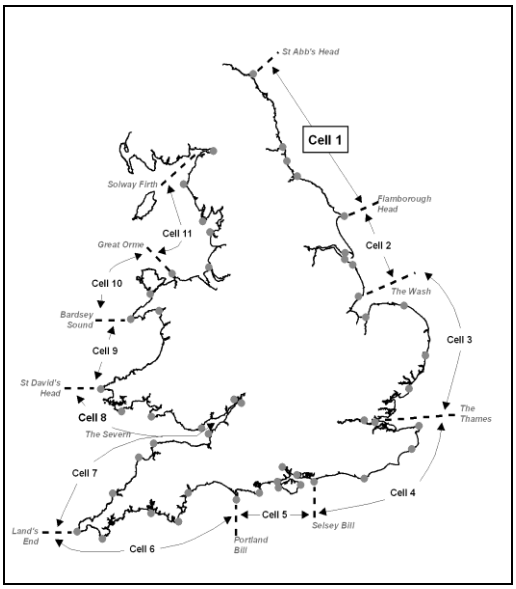


Figure 1 Sediment Cells in England and Wales

The work commenced with a three-year monitoring programme in September 2008 that was managed by Scarborough Borough Council on behalf of the North East Coastal Group. This initial phase has been followed by a five-year programme of work, which started in October 2011. The work is funded by the Environment Agency, working in partnership with the following organisations:

Northumberland County Council
North Tyneside Council
South Tyneside Council
Northumberland Coast AONB
Sunderland City Council
Durham County Council
Redcar & Cleveland Borough Council
Hartlepool Borough Council
White Scarborough Filey Borough of Scarborough
A great place to live, work & play
East Riding of Yorkshire Council
Environment Agency
Natural England
The National Trust

The main elements of the Cell 1 Regional Coastal Monitoring Programme involve:

- beach profile surveys
- topographic surveys
- cliff top recession surveys
- real-time wave data collection
- bathymetric and sea bed characterisation surveys
- aerial photography
- walk-over surveys

The beach profile surveys, topographic surveys and cliff top recession surveys are undertaken as a 'Full Measures' survey in autumn/early winter every year. Some of these surveys are then repeated the following spring as part of a 'Partial Measures' survey.

Each year, an Analytical Report is produced for each individual authority, providing a detailed analysis and interpretation of the 'Full Measures' surveys. This is followed by a brief Update Report for each individual authority, providing ongoing findings from the 'Partial Measures' surveys.

Annually, a Cell 1 Overview Report is also produced. This provides a region-wide summary of the main findings relating to trends and interactions along the entire Cell 1 frontage. To date the following reports have been produced:

Table 1 Analytical, Update and Overview Reports Produced to Date

Year		Full Measures		Partial Measures		Cell 1 Overview Report
		Survey	Analytical Report	Survey	Update Report	
1	2008/09	Sep-Dec 08	May 09	Mar-May 09		-
2	2009/10	Sep-Dec 09	Mar 10	Feb-Mar 10	July 10	-
3	2010/11	Aug-Nov 10	Feb 11	Feb-April 11	August 11	Sept 11
4	2011/12	Sep-Oct 11	Oct 12	Mar-May 12	Feb 13	-
5	2012/13	Sep 2012	Feb 13	April 13	May 13	-
6	2013/14	Sep-Oct 13	Feb 14	March 14	July 14	
7	2014/15	Sep-Oct 14	Feb 15	April 15	June 15	
8	2015/16	August 2015	Feb 16	April 16	July 16	
9	2016/17	Aug-Sep 2016	Feb 17 (*)			

(*) The present report is **Analytical Report 9** and provides an analysis of the 2016 Full Measures survey for Hartlepool Borough Council's frontage.

In addition, separate reports are produced for other elements of the programme as and when specific components are undertaken, such as wave data collection, bathymetric and sea bed sediment data collection, aerial photography, and walk-over visual inspections. For purposes of analysis, the Cell 1 frontage has been split into the sections listed in Table 2.

Table 2 Sub-divisions of the Cell 1 Coastline

Authority	Zone
Northumberland County Council	Spittal A
	Spittal B
	Goswick Sands
	Holy Island
	Bamburgh
	Beadnell Village
	Beadnell Bay
	Embelton Bay
	Boulmer
	Alnmouth Bay
	High Hauxley and Druridge Bay
	Lynemouth Bay
	Newbiggin Bay
	Cambois Bay
	Blyth South Beach
North Tyneside Council	Whitley Sands
	Cullercoats Bay
	Tynemouth Long Sands
	King Edward's Bay
South Tyneside Council	Littehaven Beach
	Herd Sands
	Trow Quarry (incl. Frenchman's Bay)
	Marsden Bay
Sunderland Council	Whitburn Bay
	Harbour and Docks
	Hendon to Ryhope (incl. Halliwell Banks)
Durham County Council	Featherbed Rocks
	Seaham
	Blast Beach
	Hawthorn Hive
	Blackhall Colliery
Hartlepool Borough Council	North Sands
	Headland
	Middleton
	Hartlepool Bay
Redcar & Cleveland Borough Council	Coatham Sands
	Redcar Sands
	Marske Sands
	Saltburn Sands
	Cattersty Sands (Skinningrove)
Scarborough Borough Council	Staithes
	Runswick Bay
	Sandsend Beach, Upgang Beach and Whitby Sands
	Robin Hood's Bay
	Scarborough North Bay
	Scarborough South Bay
	Cayton Bay
	Filey Bay

1. Introduction

1.1 Study Area

Hartlepool Borough Council's frontage extends from Crimdon Beck in the north, to the North Gare Breakwater in the south. For the purposes of this report, it has been sub-divided into four areas, namely:

- North Sands
- Hartlepool Headland
- Middleton
- Hartlepool Bay

1.2 Methodology

Along Hartlepool Borough Council's frontage, the following surveying is undertaken:

- Full Measures survey annually each autumn/early winter comprising:
    - Beach profile surveys along twelve transect lines
    - Topographic survey along part of North Sands (referred to as Hartlepool North or 'HN')
    - Topographic survey along Middleton (referred to as Hartlepool Central or 'HC')
    - Topographic survey along Hartlepool Bay (referred to as Hartlepool South or 'HS')
- Partial Measures survey annually each spring comprising:
    - Beach profile surveys along twelve transect lines
- Additionally, every five years (starting with 2008 as the baseline year), the Full Measures topographic survey at Hartlepool North is extended to fully cover the whole of North Sands and Hartlepool Headland with a topographic survey. This extends across the boundary of jurisdiction between Hartlepool Borough Council and County Durham Council.

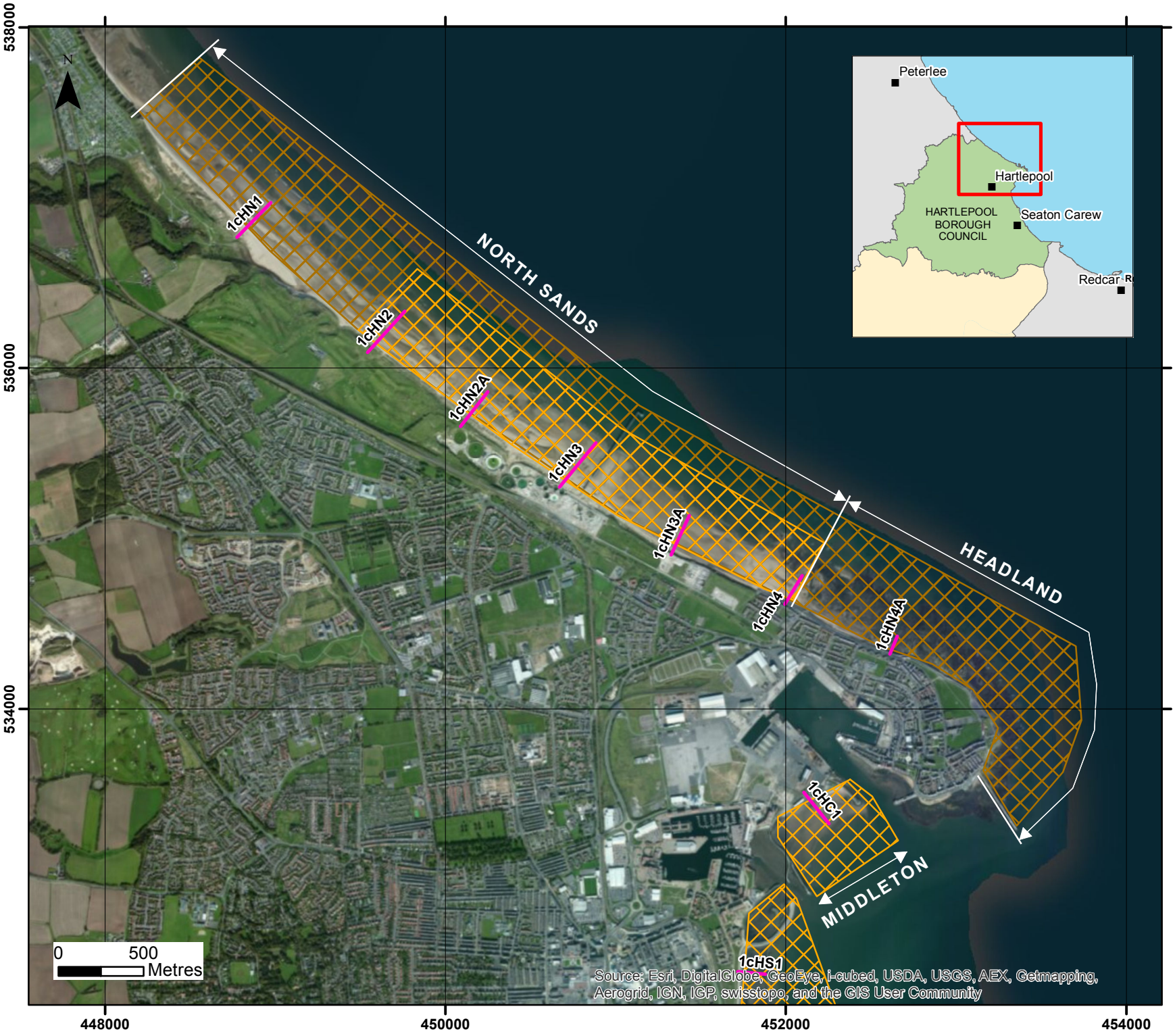
The location of these surveys is shown in Figure 2. The 2016 Full Measures survey was undertaken along this frontage on various dates between 24th August and 6th September. During this time, the weather was generally dry and sunny with force 2 to 4 breezes from the south-west. The sea state at all sites was either calm or moderate. The survey reports from Academy Geomatics document details of the weather conditions over this survey period.

All data have been captured in a manner commensurate with the principles of the Environment Agency's *National Standard Contract and Specification for Surveying Services* and stored in a file format compatible with the software systems being used for the data analysis, namely SANDS and ArcGIS. This data collection approach and file format is comparable to that being used on other regional coastal monitoring programmes, such as in the South East and South West of England.

Upon receipt of the data from the survey team, they are quality assured and then uploaded onto the programme's website for storage and availability to others and also input to SANDS and GIS for subsequent analysis. The Analytical Report is then produced following a standard structure for each authority. This involves:

- description of the changes observed since the previous survey and an interpretation of the drivers of these changes (Section 2);
- documentation of any problems encountered during surveying or uncertainties inherent in the analysis (Section 3);
- recommendations for 'fine-tuning' the programme to enhance its outputs (Section 4); and
- providing key conclusions and highlighting any areas of concern (Section 5).

Data from the present survey are presented in a processed form in the Appendices.



Key

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 1 Hartlepool Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:30,000

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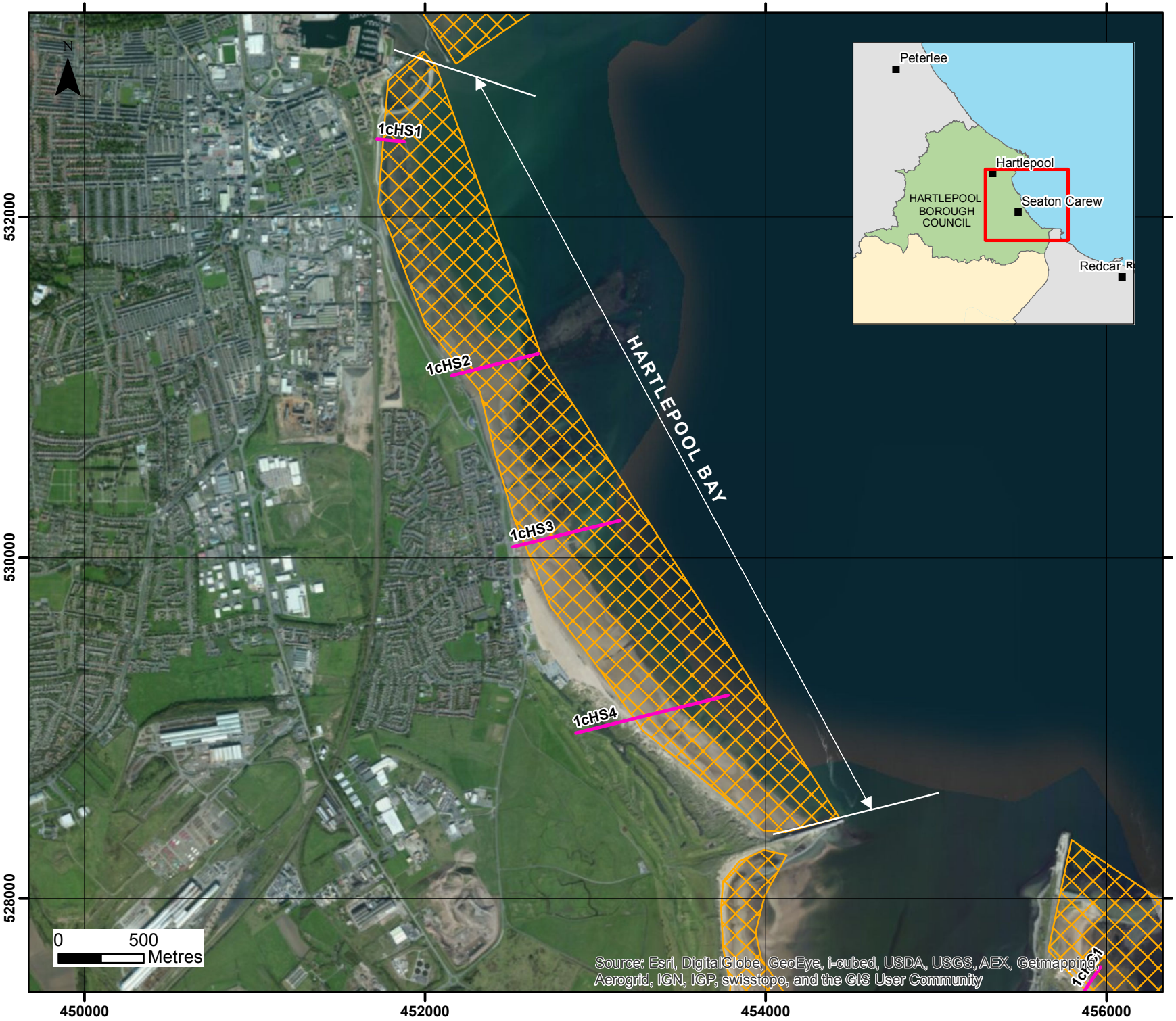

Key

SURVEY LOCATIONS

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- Annual
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- yearly
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(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 2 Hartlepool Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:30,000

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Key

SURVEY LOCATIONS

Topographic Profiles

- Annual
- Bi-Annual

Topographic Surveys

- 6 monthly
- yearly
- 5 yearly

(Indicative Survey Extents shown)

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Figure 2 - Map 3 Hartlepool Borough Council Frontage

Analytical Report
Topo Surveys

Drawing Scale at A4 1:12,000

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2. Analysis of Survey Data

2.1 North Sands

Survey Date	Description of Changes Since Last Survey	Interpretation
30th-31st August 2016	**Beach Profiles:** North Sands is covered by four beach profile lines during the Full Measures survey (Appendix A). They were last surveyed in April 2016. Profile **1cHN1** is located within Durham County Council's area of responsibility, about 400m north of the outfall of Crimdon Beck, but is reported here so changes can be interpreted in association with those observed elsewhere along North Sands at HN2, HN3 and HN4. The beginning of profile **1cHN1** between 0m and 70m change covers dunes and has not changed. The small berm at chainage 80m noted in the April 2016 survey has moved seawards by c.10m and increased in height by 0.4m. Between 80m chainage and 190m there has generally been accretion of up to 0.4m. From 190m seawards, the profile has dropped by up to 0.4m compared to April 2016. The profile is at its highest recorded level through the upper and middle beach but at a medium level compared to previous surveys through the lower foreshore. At Profile **1cHN2,** the profile has not changed on the section with dunes. Between chainage 70m and 105m the beach level has lowered by up to 0.6m, with the berm crest moving seawards by c.10m. Between 105m and 130m chainage the channel feature noted in the April 2016 survey has been infilled by up to 0.6m, with erosion of up to 0.8m seawards of the channel up to chainage 200m. The lower foreshore from 200m seawards shows accretion. Overall the profile is smoother than that recorded in April 2016 with a shallower gradient, and the profile is at a medium level compared with previously recorded surveys. **Profile 1cHN2a** was established in October 2011 and runs through the dunes close to North Sands. The foredune which had started to re-accrete in the September 2015 has continued to accrete marginally. There has been little change compared to the April 2016 survey up to chainage 90m where a small berm has formed up to 0.6m high. From chainage 110m to 170m there has been erosion of up to 0.4m, with the formation of another berm up to 0.3m high between 170m and 205m. Seaward of 205m	The profiles show a more consistent change than the previous full measures survey in 2015, with accretion in the upper and lower beach (with the formation of berms), and erosion in the middle beach across the whole bay. The beach levels are now at a medium level across most of the bay compared to the range from previous surveys. This is a reversal of the trend seen in the 2015 full measures survey where the eastern part of the bay was more dominated by erosion. **Longer term trends**: The 2016 full measures survey is not entirely in line with the longer term trends which suggest accretion in the west, stability in the middle of the bay and erosion in the east.

Survey Date	Description of Changes Since Last Survey	Interpretation
	the profile shows lower levels. Overall the profile has steepened compared to the April 2016 survey and is at a medium level compared with previously recorded surveys. At Profile **1cHN3** there has been little change of the dunes but the crest of the fore-dune at 35m chainage has accreted by 0.4m. A berm of up to 0.5m height has developed at the toe of the foredune since the April 2016 survey, The majority of the beach profile shows erosion with a loss of up to 0.4m between 75m chainage and 220m, being the lowest recorded level. However seaward of chainage 220m the foreshore has accreted slightly by up to 0.1m. At Profile **1cHN3a** there has been stability down to the dune face at 20m chainage. The drop in beach level at the toe of the dunes recorded since the April 2015 survey has shown some signs of recovery, with levels accreting by 0.5m, back to the September 2015 levels. The remainder of the profile mainly shows erosion of up to 0.2m with the exception of the formation of two small berms up to 0.4m in height between 120m and 160m, and seawards of 190m. Overall the level is in the mid-to-low range of the previous profiles, with the exception of the seaward end (chainage 200m onwards) which is relatively high. At Profile **1cHN4** there has been an accumulation of up to 0.8m high at the toe of the rock protrusion at chainage 15m. The sand mound between chainage 40m and 65m recorded since April 2015 has been removed with erosion of up to 0.3m. Between chainage 65m and 105m there has been an accumulation of sand across the previously exposed rock platform of up to 0.4m. From 105m to the end of the survey the rocks on the bottom of the beach are exposed, which is usual for this profile. Overall the profile is towards the low end of the range recorded from previous surveys. At Profile **1cHN4a** there has been a large accumulation of sand of up to 0.7m across the upper beach between chainage 10m and 45m covering the previously exposed rock platform. Seawards of 45m chainage the rock platform is exposed and shows little change to previous surveys, with the exception of a small accumulation of sand between 55m and 70m chainage Overall the profile is at a medium-low level compared to the previous recorded surveys.	

Survey Date	Description of Changes Since Last Survey	Interpretation
	Topographic Survey: North Sands is covered by an annual topographic survey. Data from the 2016 Full Measures survey have been used to create a DGM (Appendix B – Map 1) using a GIS package. The majority of the frontage is characterised by shore-parallel contours, except in the vicinity of outfalls, groynes and the pier where contours change direction. The GIS has also been used to calculate the differences between the Autumn 2015 and Autumn 2016 topographic surveys, as shown in Appendix B – Map 3, to identify areas of net erosion and accretion. There are two parts to this area of interest with the beach on each side of the central pier behaving differently. To the west of the pier erosion dominates with losses of over 1.5m in places. The beach lowering is concentrated in the upper-mid beach; however there are some patches of accretion. To the east of the pier the changes in beach level are not as severe and accretion is more dominant, however there are still patches of erosion in the upper-mid beach. Both sides of the pier show a narrow band of accretion at the uppermost section of beach along the vast majority of the length of the survey. The lower foreshore of both sides are also predominantly areas of accretion.	

2.2 Middleton

Survey Date	Description of Changes Since Last Survey	Interpretation
24th August 2016	**Beach Profiles:** Middleton is covered by one beach profile line during the Full Measures survey (Appendix A). The beach at Profile **1cHC1** between the seawall at 50m chainage and 150m chainage shows accretion of up to 0.2m. Seawards of 150m there has been erosion of 0.3m. Overall the beach is at a medium level compared to the range from previous surveys. .	The beach profile showed a gain in the upper beach and a loss in the lower beach and steepening overall. The difference plot for Middleton shows a zone of erosion across the mid beach. In front of the headland the difference plots show a patchy distribution of change due to the thin but mobile cover of sand here. **Longer term trends**: The beach is in the mid-range of the previously recorded levels but is relatively steep. The fact that the profile was recorded in the end of August means that the beginning of the autumn storms would not have had an effect of lowering this beach.
	Topographic Survey: The frontage is covered by an annual topographic survey between Middleton Jetty and North Pier. Data from the 2016 Full Measures survey have been used to create a DGM (Appendix B – Map 1) using GIS software. Beach contours indicate a steeper beach in the east than the west, with the contours locally affected by pipelines and groynes. In the Autumn 2013 survey, differences between the eastern and western ends of the beach were less marked. Earlier years show a similar topography to 2014 and 2015. The GIS has also been used to calculate the differences between the Autumn 2015 and Autumn 2016 topographic surveys, as shown in Appendix B – Map 3, to identify areas of net erosion and accretion. The beach near the Headland shows a patchy distribution of accretion and erosion, with there generally being little change in the east and erosion in the west. At Middleton erosion dominates in the west with accretion in the east. The changes observed at Middleton beach over the year are modest at less than ±0.75m.	

2.3 Hartlepool Bay

Survey Date	Description of Changes Since Last Survey	Interpretation
5th – 6th September 2016	**Beach Profiles:** Hartlepool Bay is covered by four beach profile lines during the Full Measures survey (Appendix A). The profiles were last surveyed in March 2016. Sea coalers had been banned from driving onto the beach in 2013 but on 28th March 2015 the gates were opened and they were allowed to remove coal from the beach again (Hartlepool Mail). Profile **1cHS1** is located approximately 150m south of the root of the South Pier. The profile starts at the wall to the rear of the promenade and extends across the promenade, over the fronting concrete splash wall and down the sloping face of the rock armour revetment before reaching the beach. There has been accretion of up to 0.2m along the entire beach profile. The beach level is high along the entire profile and is at its highest level since monitoring began and has been getting progressively higher. There has been accretion of up to 0.5m along all but the most seaward end of Profile **1cHS2**, burying the berms which had developed in the April 2016 survey**.** Seaward of chainage 250m the beach has lowered by up to 0.4m. The overall effect has been to steepen the beach. The September 2016 profile is the highest recorded through the upper and middle beach and there has been progressive accretion. At profile **1cHS3** there has been accretion of up to 0.4m on the upper beach between chainage 30m and 75m. Between chainage 75m and 110m there has been some slight lowering to the beach of less than 0.2m. Between 110m and 200m a berm has formed up to 0.4m high. Whilst the lower foreshore seaward of 200m has eroded by up to 0.5m, steepening the toe of the beach dramatically, similar to the beach toe in the March 2014 survey. Up to chainage 190m the beach profile is one of the highest recorded. The profile **1cHS4** is located further south, around 1km north of the North Gare breakwater in an area of undefended dunes at Seaton Sands. The profile covers approximately 325m of dunes before the beach. The dune section is stable, with a foredune continuing to accrete at around 320m chainage with 0.3m of growth since April 2016. The deepening of the depression between the main dune and the foredune has halted since April 2016, showing 0.1m of accretion. . The berm developed in the April	The profiles in Hartlepool Bay are all similar to the levels shown in the November 2015 and April 2016 surveys. This is likely to be due to the beach accreting more in the summer before the levels drop back down following the autumn storms. Profiles HS1-HS3 have all shown progressive accretion since the beginning of the surveys. The beach levels are high. The high beaches may be due to the northward transport of sediment from the dunes. **Longer term trends**: The profiles have shown stability over 2016. The accretion of the northern three profiles continues. On the southern profile, HS4, the beach had steepened which could be a precursor to erosion. The foredune continues to develop although footfall may be damaging it and leading to erosion.

Survey Date	Description of Changes Since Last Survey	Interpretation
	2016 survey at chainage 370m has grown by 0.3m, with the rest of the upper beach increasing by up to 0.6m down to chainage 470m. From chainage 470m the beach level has dropped significantly by up to 1m forming a depression 90m across. The profile is mid-high in the range of previous surveys across the upper beach, but from chainage 470m it is the lowest on record.	
	Topographic Survey: Hartlepool Bay is covered by an annual topographic survey between the South Pier and the North Gare Breakwater. Data from the 2016 Full Measures survey have been used to create a DGM (Appendix B – Map 2) using a GIS software package. The plot shows the two smaller bays within the larger Hartlepool Bay frontage. These smaller bays are separated by a slight promontory at Carr House Sands between Hartlepool and Seaton Carew. The beach contours are generally shore parallel, except where linear features (e.g. outfalls) and rock outcrops are present, such as in the northern part of Seaton Sands. Elevations at the rear of the beach are lowest in the north of the survey area near South Pier and higher further south. The GIS has also been used to calculate the differences between the Autumn 2015 and Autumn 2016 topographic surveys, as shown in Appendix B – Map 4, to identify areas of erosion and accretion. The changes recorded over 2016 show a dominance of accretion along both bays and across the full beach. The changes observed over the northern bay are modest at less than ±0.75m. In the southern bay there are some small areas of erosion in the mid and lower beach, but the overall trend is still dominated by accretion. The scale of change is greatest towards the southern end of the bay with over ±1m change.	

2.4 North Gare

Survey Date	Description of Changes Since Last Survey	Interpretation
29th October 2016	**Topographic Survey:** North Gare is covered by an annual topographic survey between the North Gare Breakwater and the Seaton on Tees Channel. The area is designated as the Teesmouth National Nature Reserve. Surveys have been carried out since Autumn 2011. Data from the 2016 Full Measures survey have been used to create a DGM (Appendix B – Map 3) using GIS software. The beach contours recorded in 2016 show the promontory and the contours run shore parallel to the beach in the north. In the south of the study area the contours diverge from the shore line and there is an extensive flat area between the shoreline and MHW. However, the lower beach and foreshore are much steeper in the south of the survey area than in the north. The GIS has also been used to calculate the differences between the Autumn 2015 and Autumn 2016 topographic surveys, as shown in Appendix B – Map 6, to identify areas of net erosion and accretion. The difference plot shows that there are alternating shore parallel bands of accretion and erosion in the north, with accretion dominating the lower foreshore, except for an area of erosion in the north at the end of the gravel bank. The erosion tends to be in the mid beach, with some erosion in the upper beach at the northern end. In the southern part of the survey area, to the north and landward of the promontory there is little change, with some patchy small scale accretion. Seaward of the promontory the pattern is also patchy with accretion dominating, especially in the lower foreshore. However there are some small areas of erosion in a band running north-east along the gravel bank from the end of the promontory. Overall there are more areas of accretion across the survey area; however the biggest magnitude of change is the area of erosion at the northern end of the survey.	The changes seen in the 2016 Full Measures survey is the continuation of the trends seen in the previous survey, with the movement of sand bars across the shore face in the north of the survey area, and accretion on the seaward side of the promontory.

3. Problems Encountered and Uncertainty in Analysis

Beach profile HN1 is located within Durham County Council's area of responsibility but has been reported here so changes can be interpreted in association with those observed elsewhere along North Sands, along HN2, HN3 and HN4.

At Hartlepool North the start of section 1cHN3 was behind a site fence. A new revetment was also being built at the eastern end of the site to create a new sea defence.

At Middleton there was no access to the upper section of profile 1cHC1.

At North Gare the area south of breakwater difficult to survey due to very soft sand.

4. Recommendations for 'Fine-tuning' the Monitoring Programme

The surveyors noted that the area of saltmarsh in the south-east corner of the North Gare survey area should be excluded from future surveys to avoid disturbing wildlife.

5. Conclusions and Areas of Concern

- At North Sands, the beach profiles show a more consistent change than the previous full measures survey in 2015 and that the beach is now at a medium level across most of the bay. This is a reversal of the trend seen in the 2015 full measures survey where the eastern part of the bay was more dominated by erosion.
- At Middleton, the centre of the bay has eroded over 2016. The continuing erosion of the beach is expected because there are no sources of sediment to the Middleton frontage. The beach in front of the headland had a patchy distribution of change in 2015.
- The majority of changes through 2016 in Hartlepool Bay were modest. Profiles HS1-3 show progressive accretion, which is also supported by the topographic survey difference plot.
- The topographic plots show a continuation of the elevation changes observed since 2013 at North Gare. Throughout 2016 there was modest accretion overall.
- There is no cause for concern at any of these areas.

Appendices

Appendix A

Beach Profiles

Beach Profile

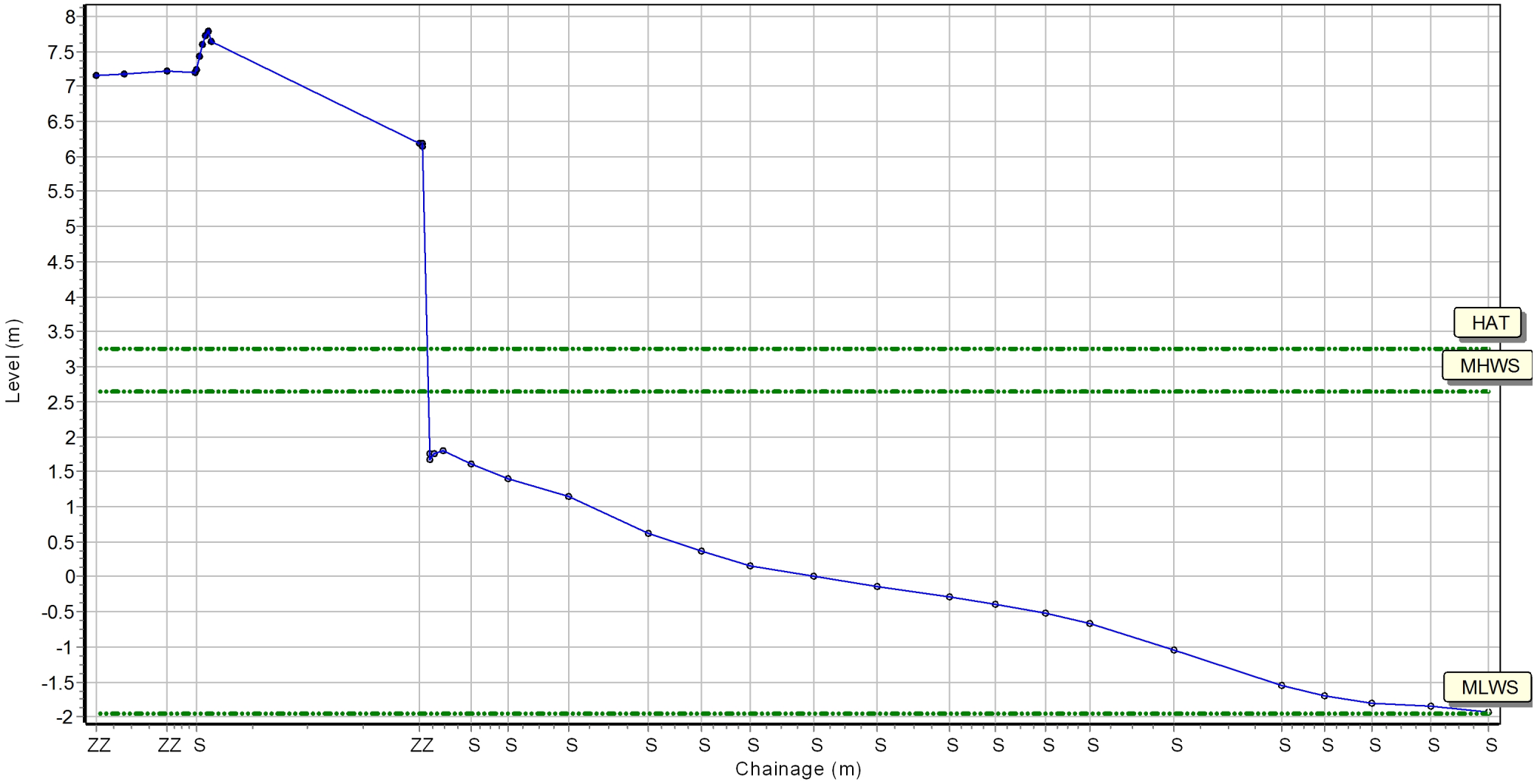
Location: **1cHC1**

Date: 24/08/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 452108.075 **Northing:** 533506.119 **Profile Bearing:** 150 from North



Beach Profile

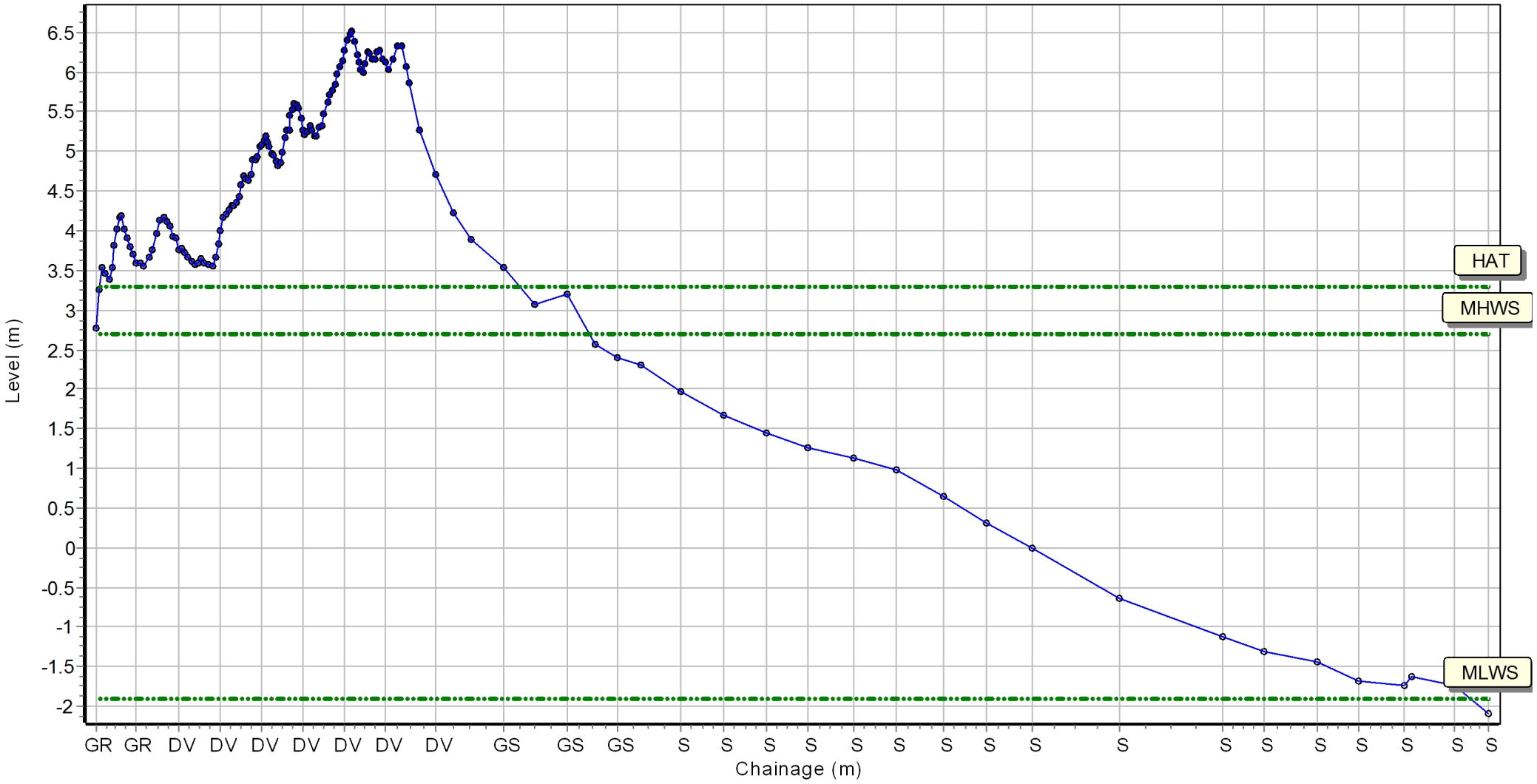
Location: **1cHN1**

Date: 31/08/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 448779.624 **Northing:** 536767.42 **Profile Bearing:** 44 from North



Beach Profile

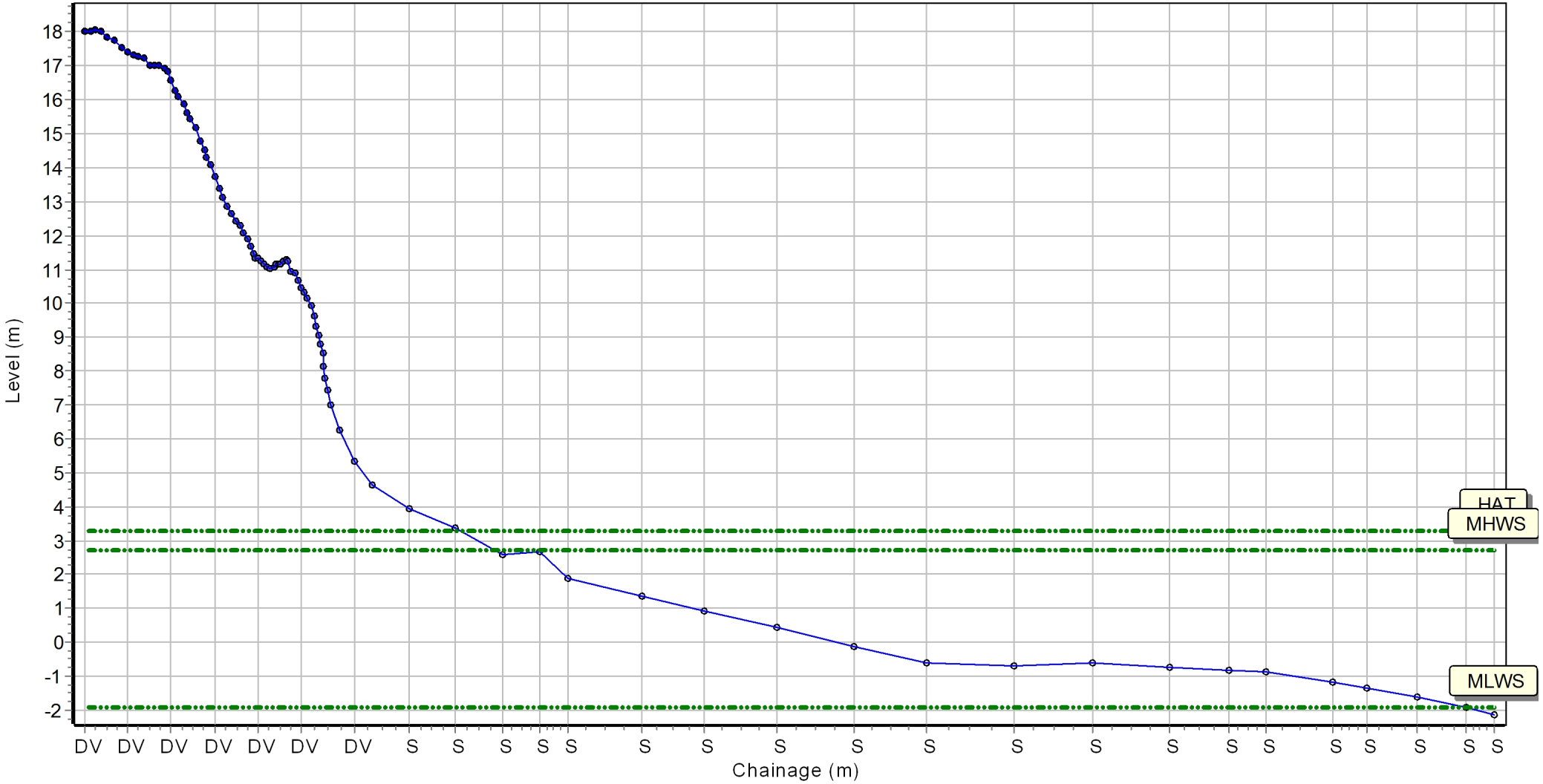
Location: **1cHN2**

Date: 31/08/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 449547.217 **Northing:** 536095.458 **Profile Bearing:** 42 from North



Beach Profile

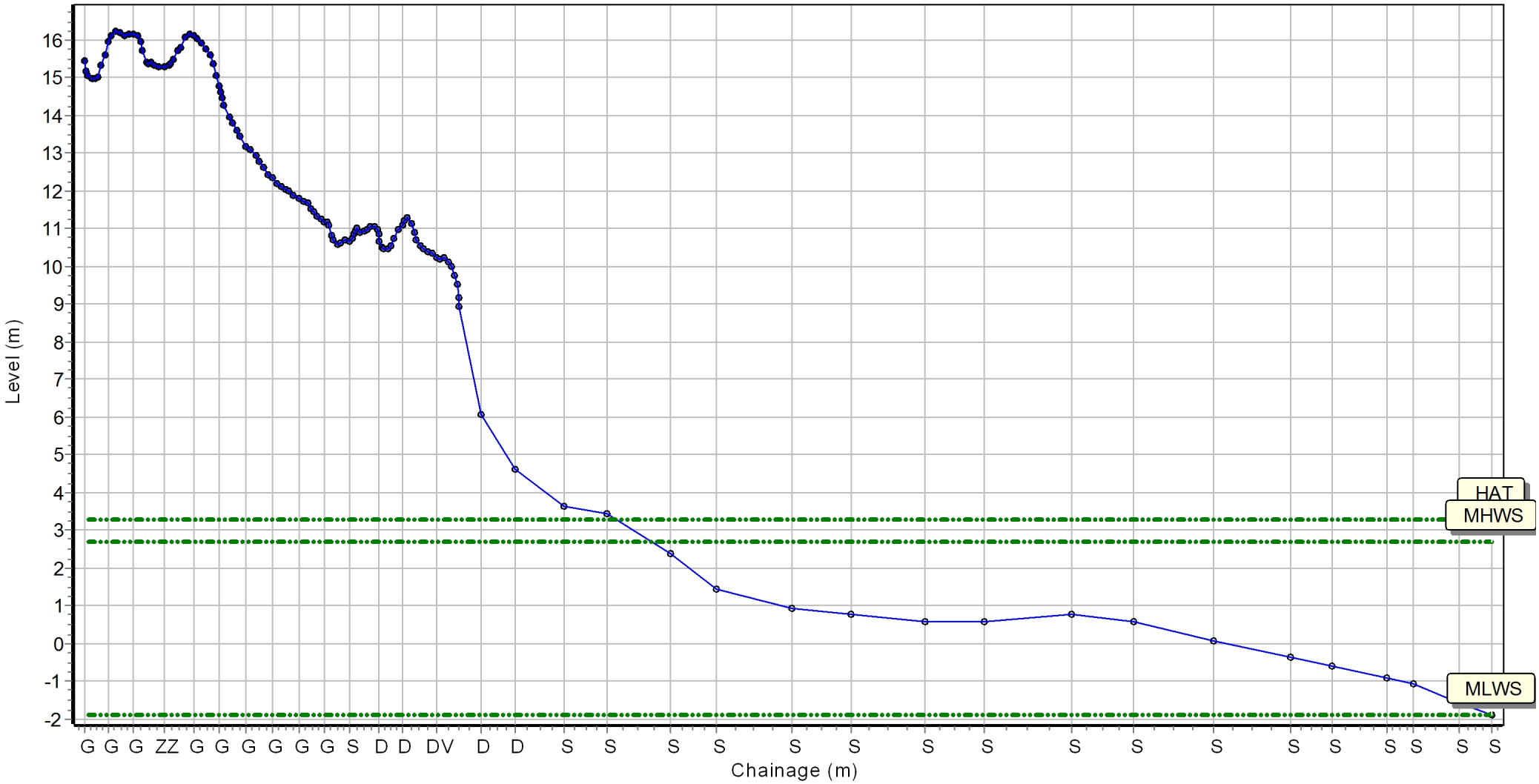
Location: **1cHN2A**

Date: 31/08/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 450088.047 **Northing:** 535658.212 **Profile Bearing:** 39 from North



Beach Profile

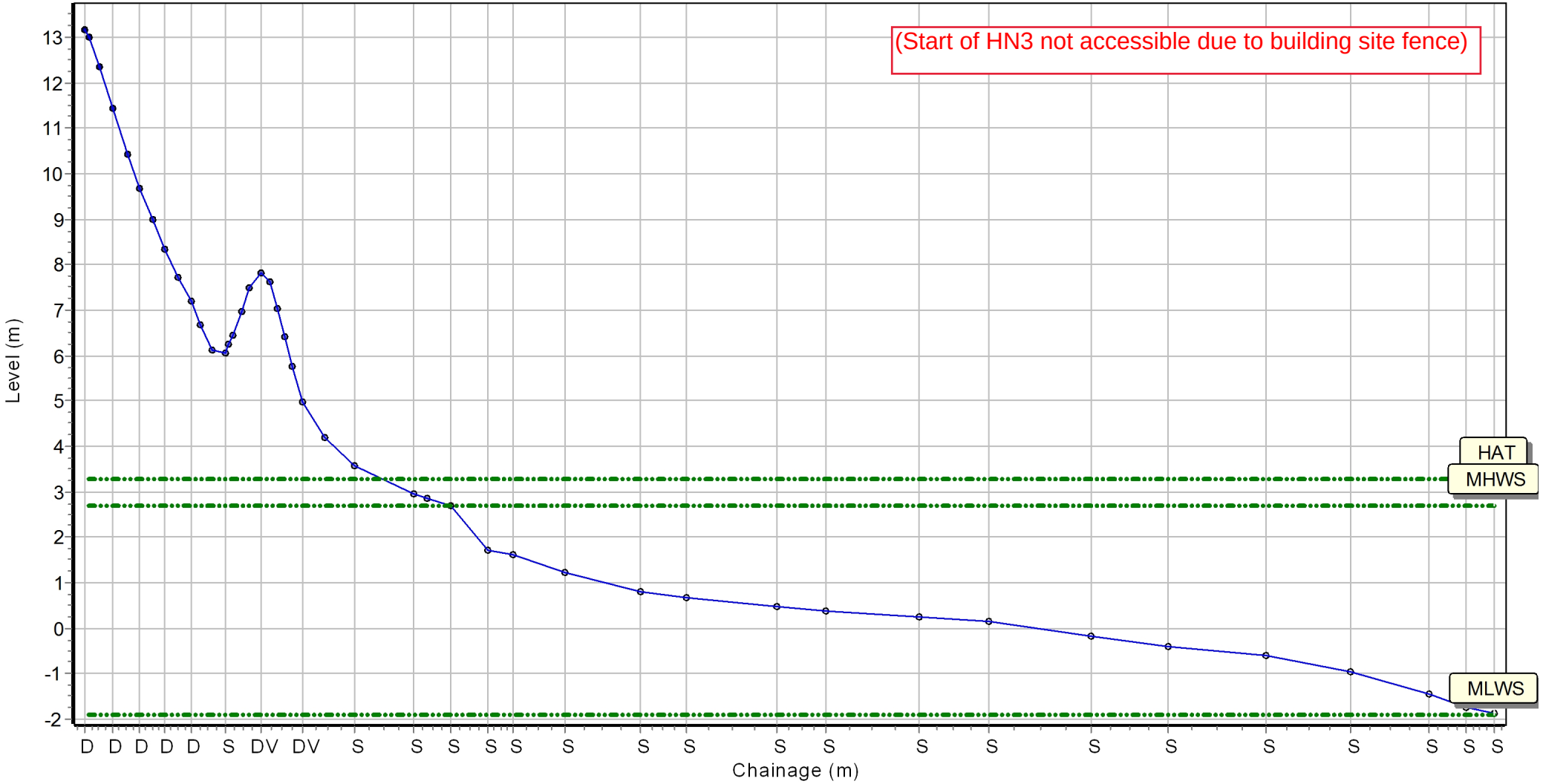
Location: **1cHN3**

Date: 31/08/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 450674.424 **Northing:** 535305.141 **Profile Bearing:** 30 from North



Beach Profile

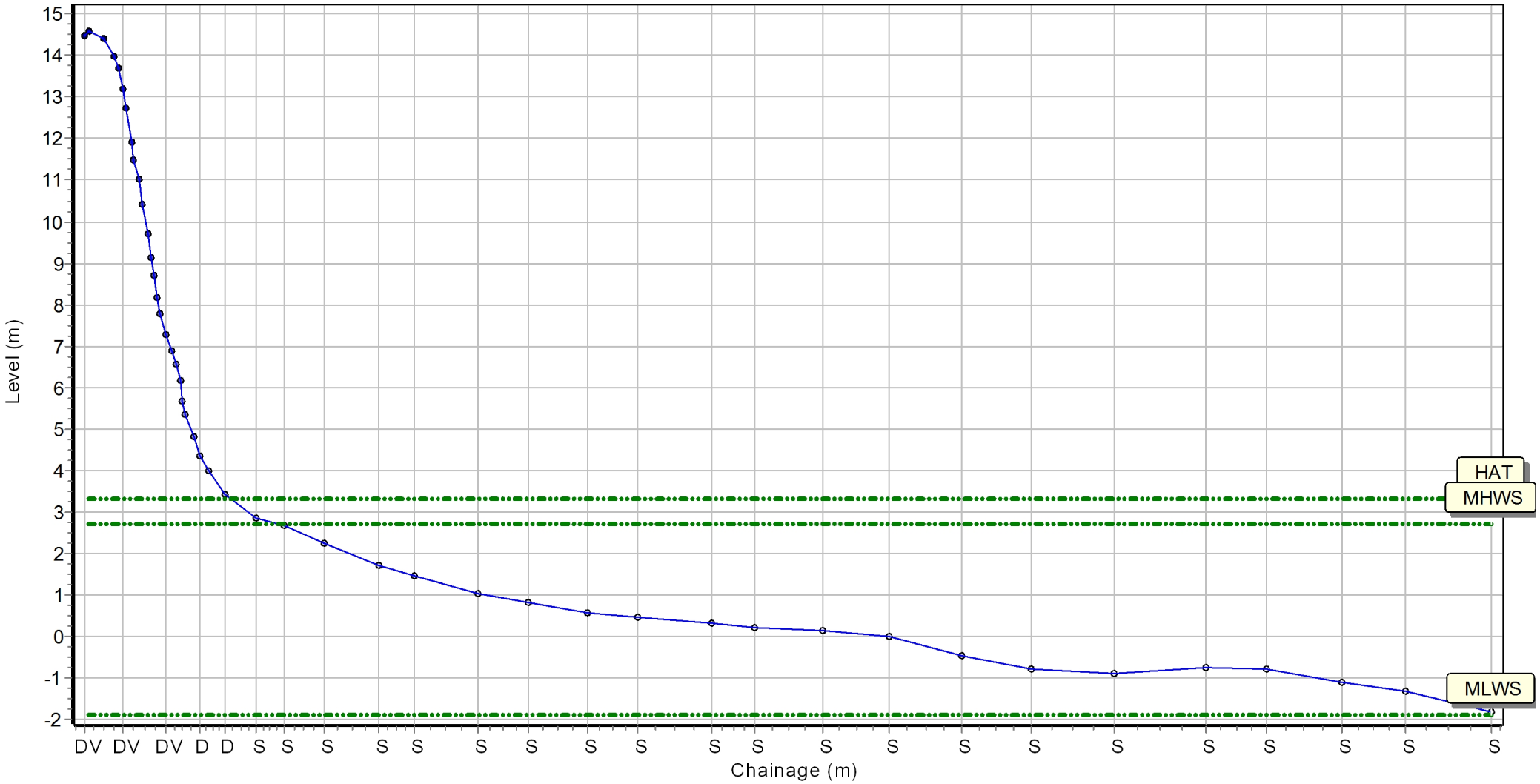
Location: **1cHN3A**

Date: 31/08/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 451324.71 **Northing:** 534903.35 **Profile Bearing:** 25 from North



Beach Profile

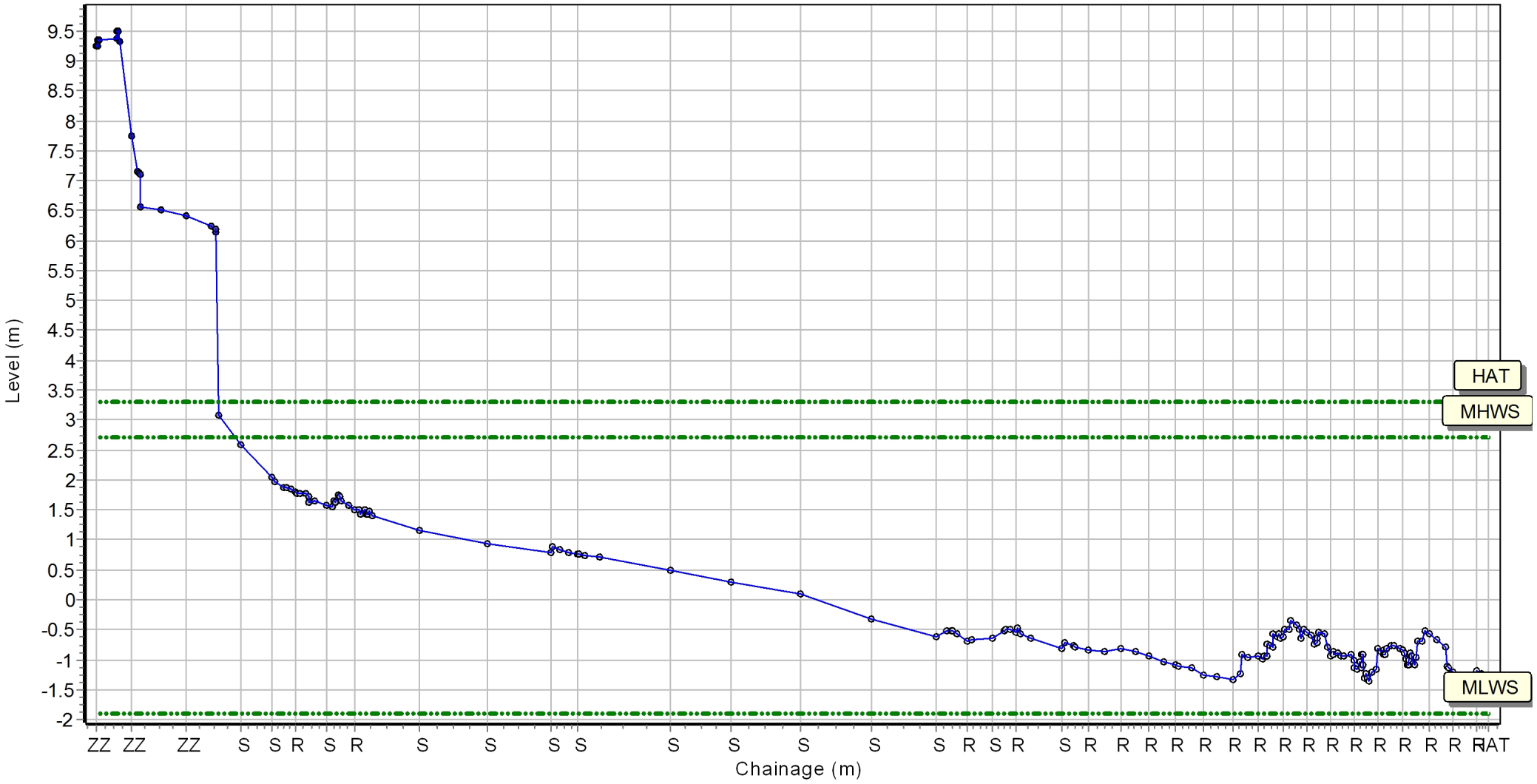
Location: **1cHN4**

Date: 31/08/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 451997.114 **Northing:** 534616.627 **Profile Bearing:** 25 from North



Beach Profile

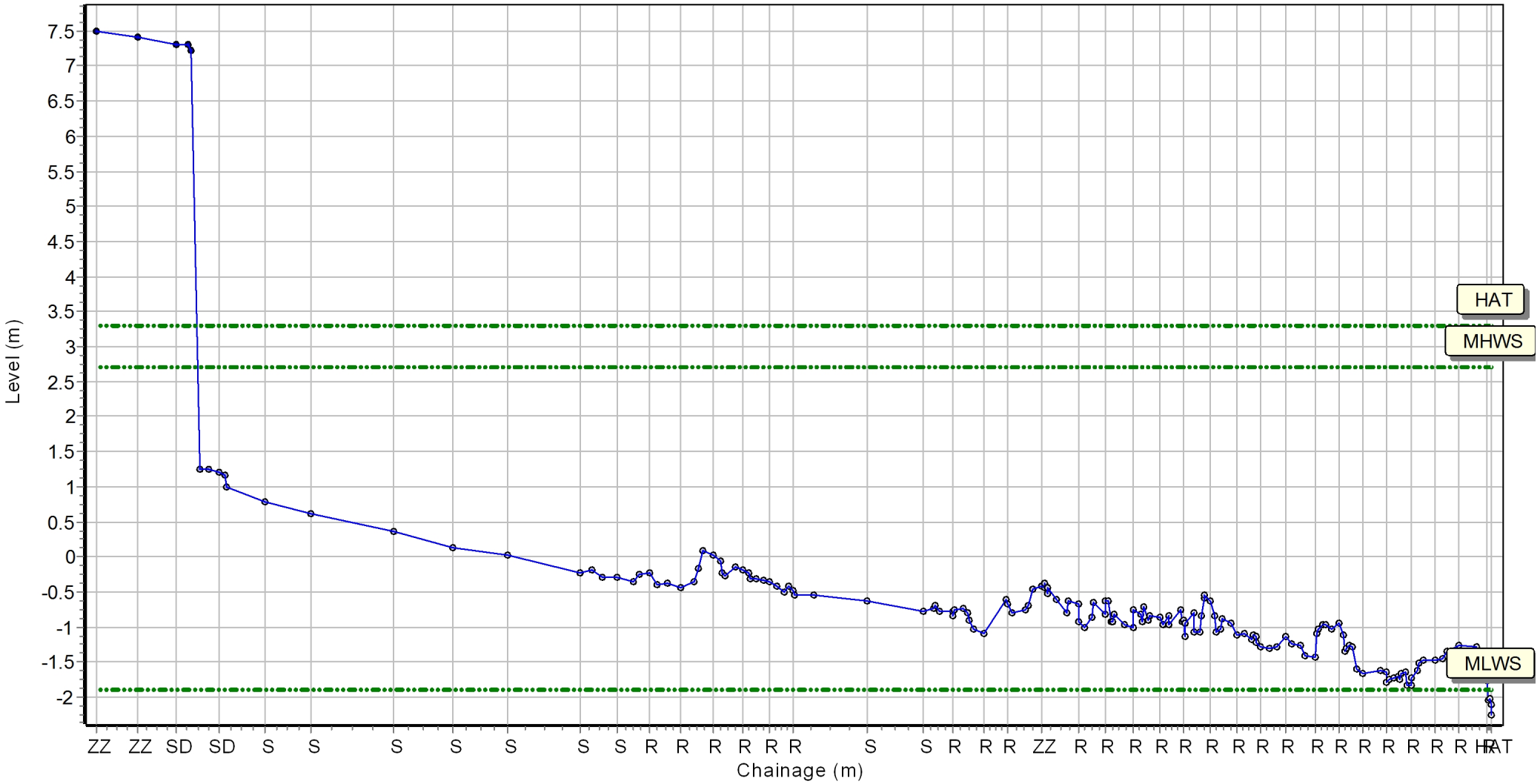
Location: **1cHN4A**

Date: 31/08/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 452610.565 **Northing:** 534321.038 **Profile Bearing:** 23 from North



Beach Profile

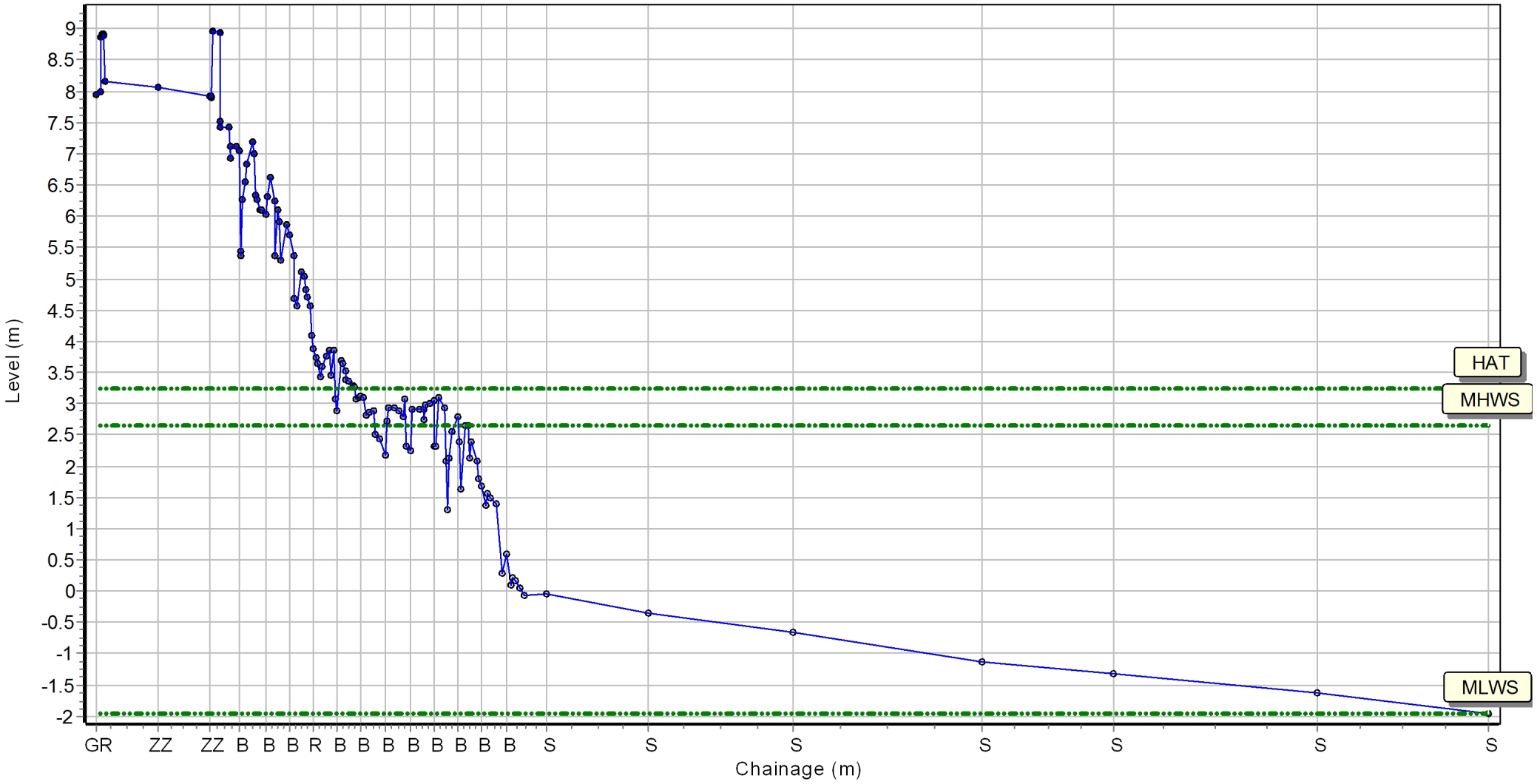
Location: **1cHS1**

Date: 06/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 451718 **Northing:** 532455 **Profile Bearing:** 95 from North



Beach Profile

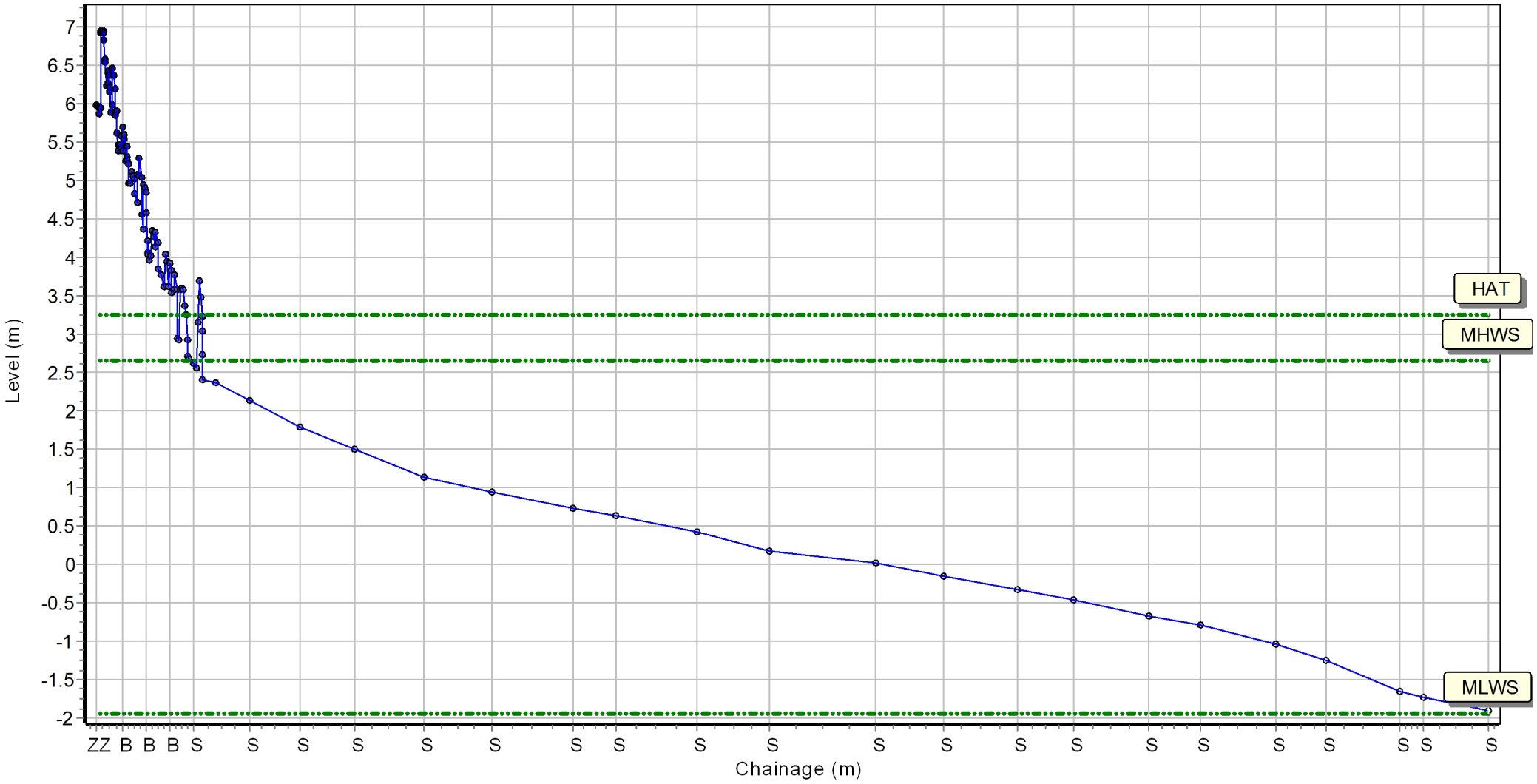
Location: **1cHS2**

Date: 06/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 452160.59 **Northing:** 531071.39 **Profile Bearing:** 77 from North



Beach Profile

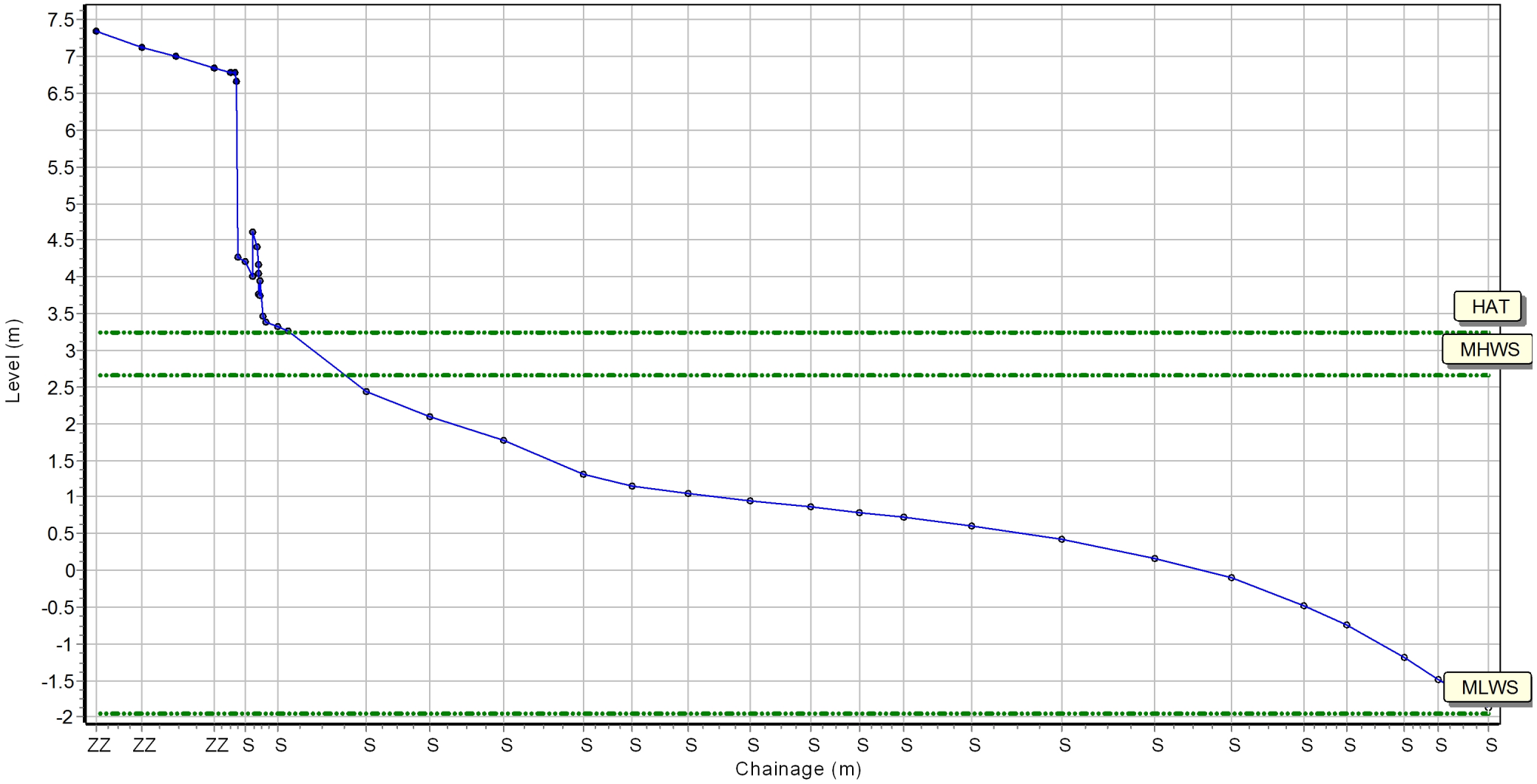
Location: **1cHS3**

Date: 06/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 452517.25 **Northing:** 530064.57 **Profile Bearing:** 76 from North



Beach Profile

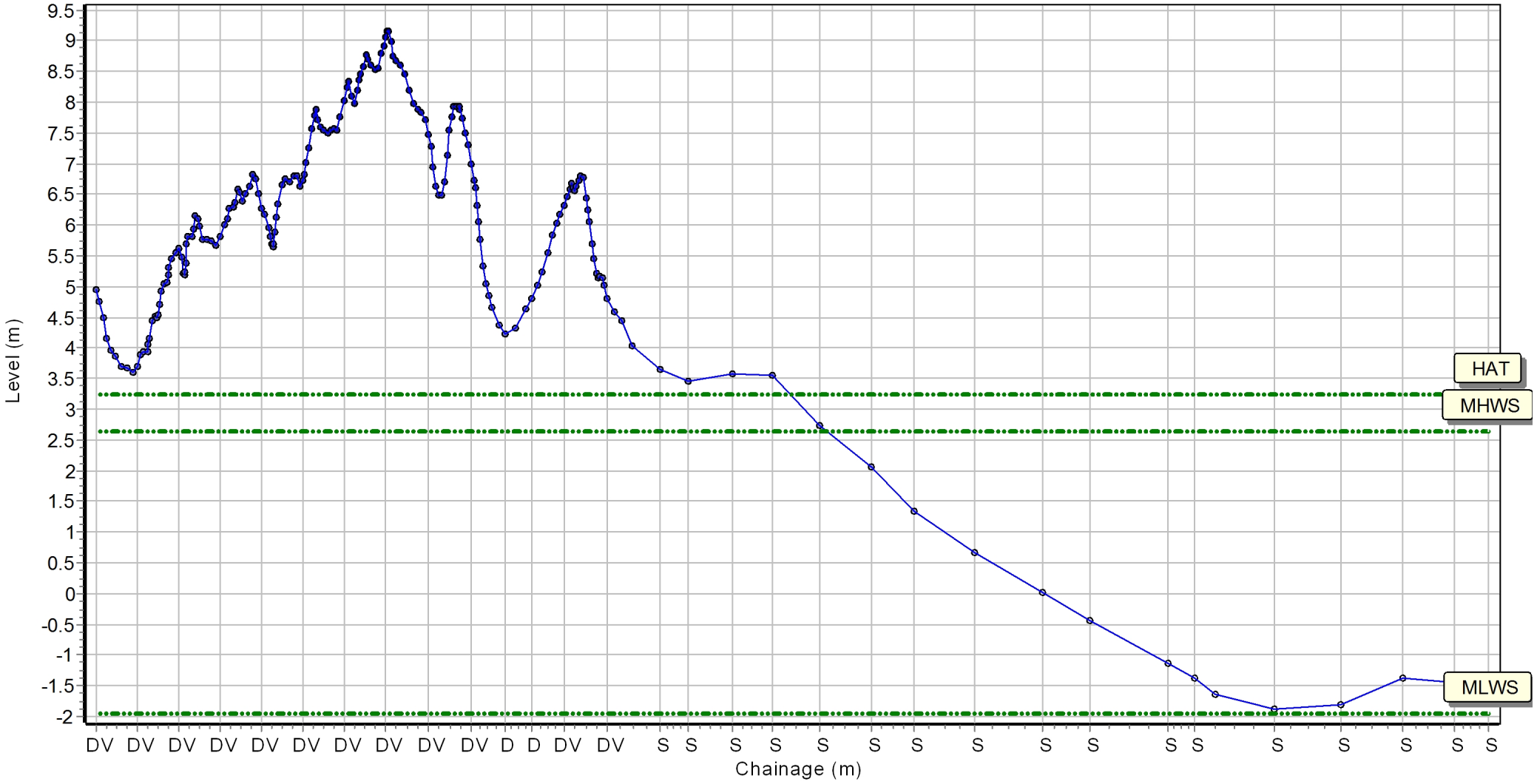
Location: **1cHS4**

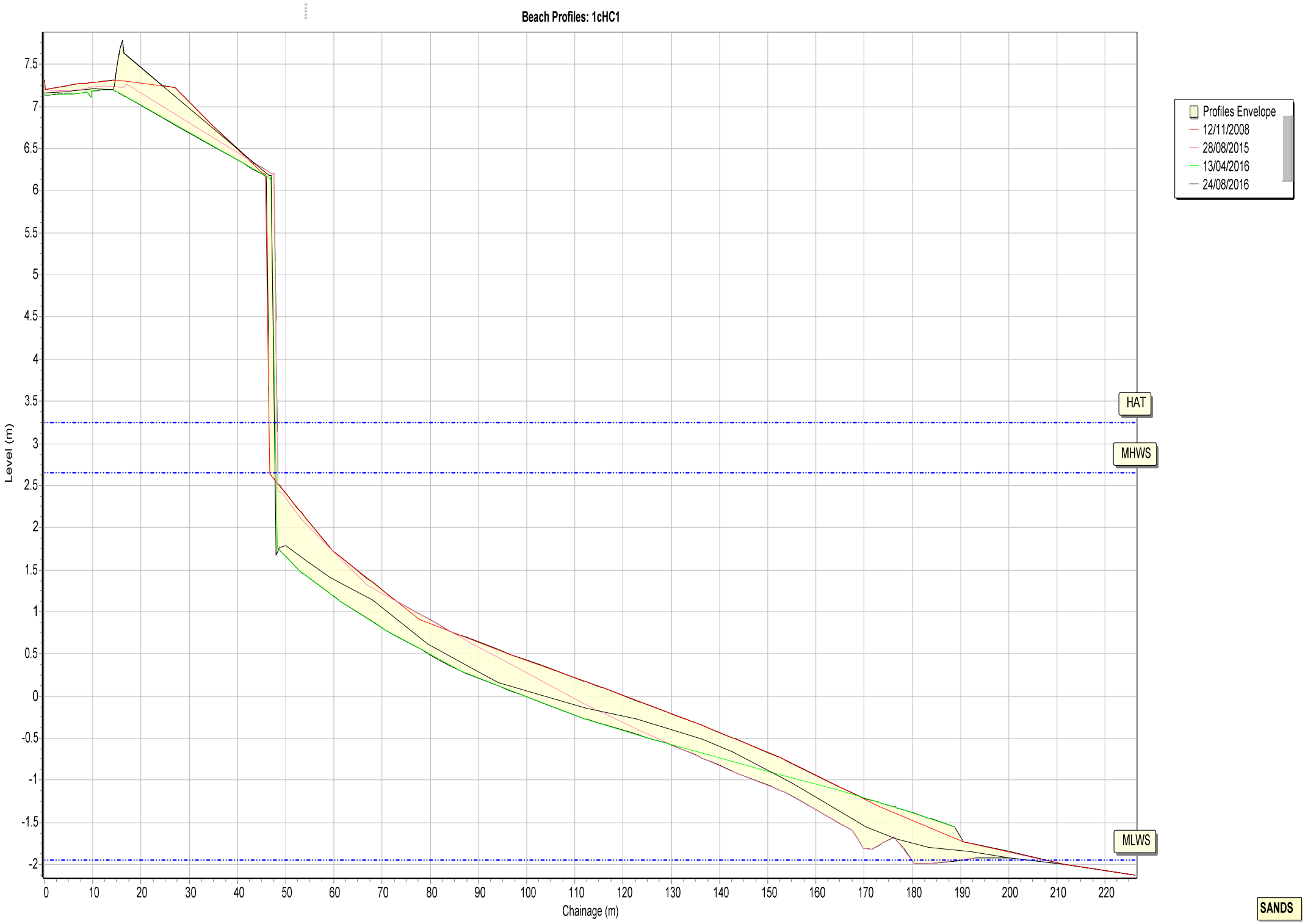
Date: 06/09/2016 **Inspector:** AG **Low Tide:** **Low Tide Time:**

Wind **Sea State:** **isibility:** **Rain:**

Summary: 2016 Full Measures Topo Survey

Easting: 452889 **Northing:** 528971 **Profile Bearing:** 76 from North

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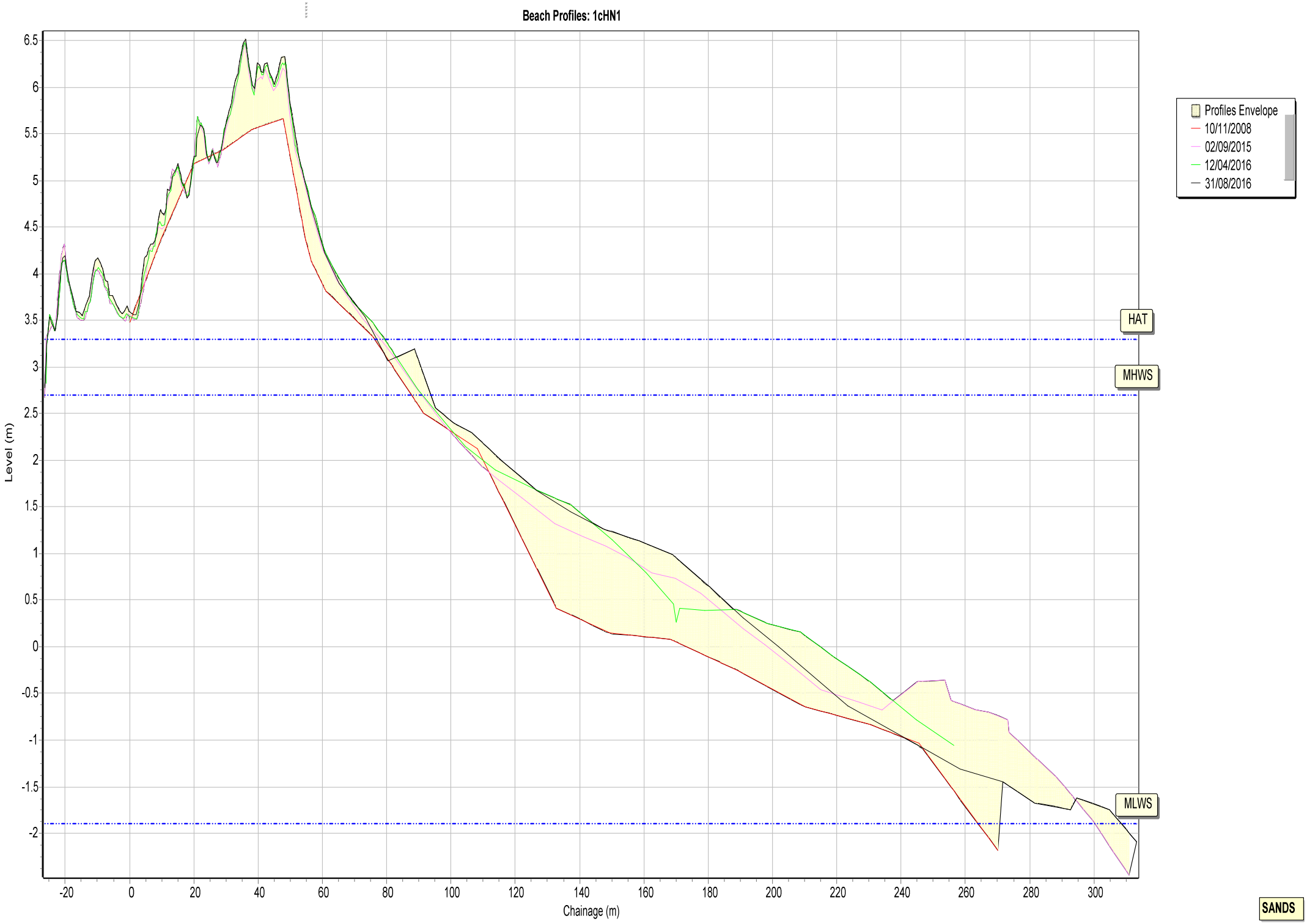
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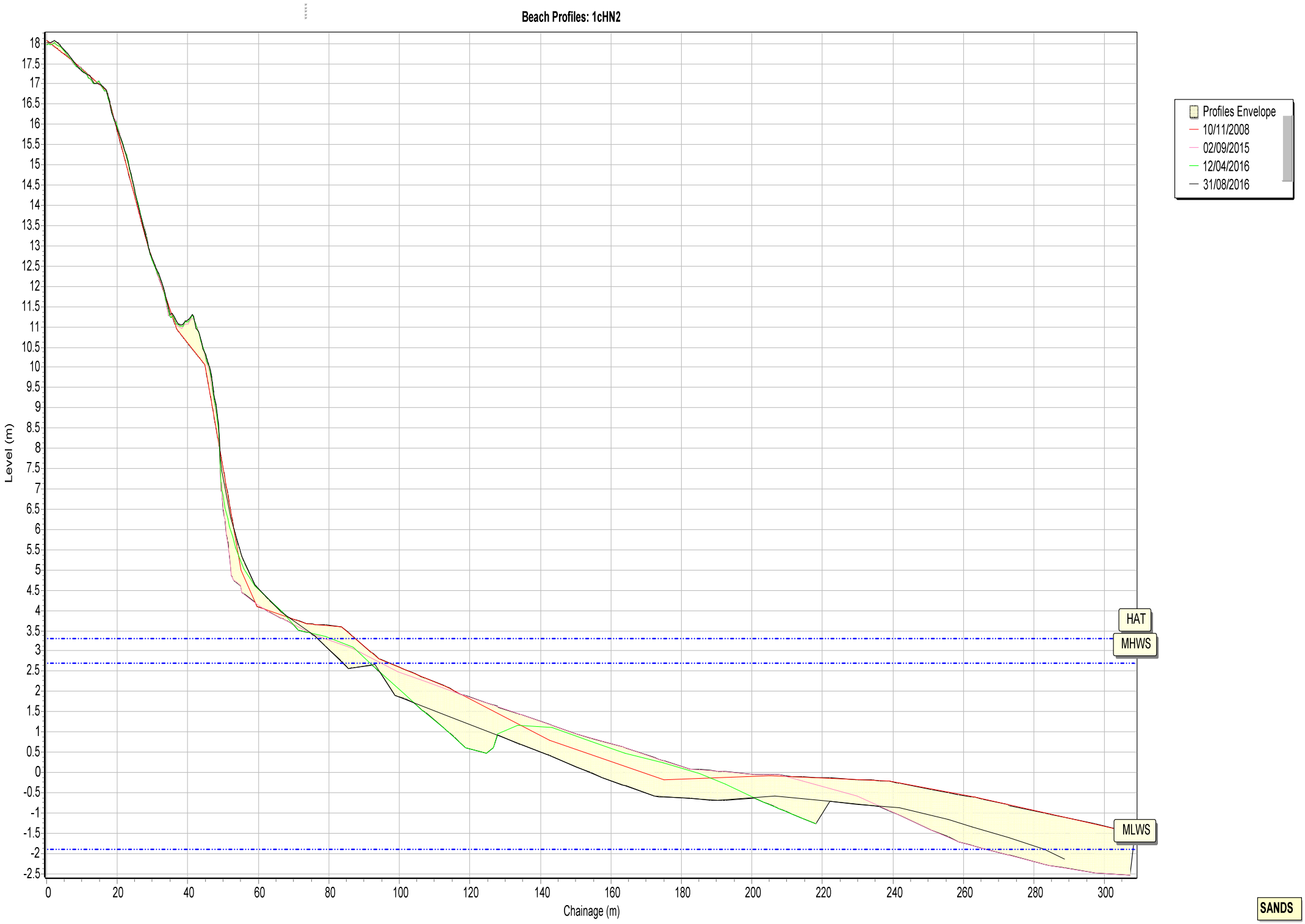
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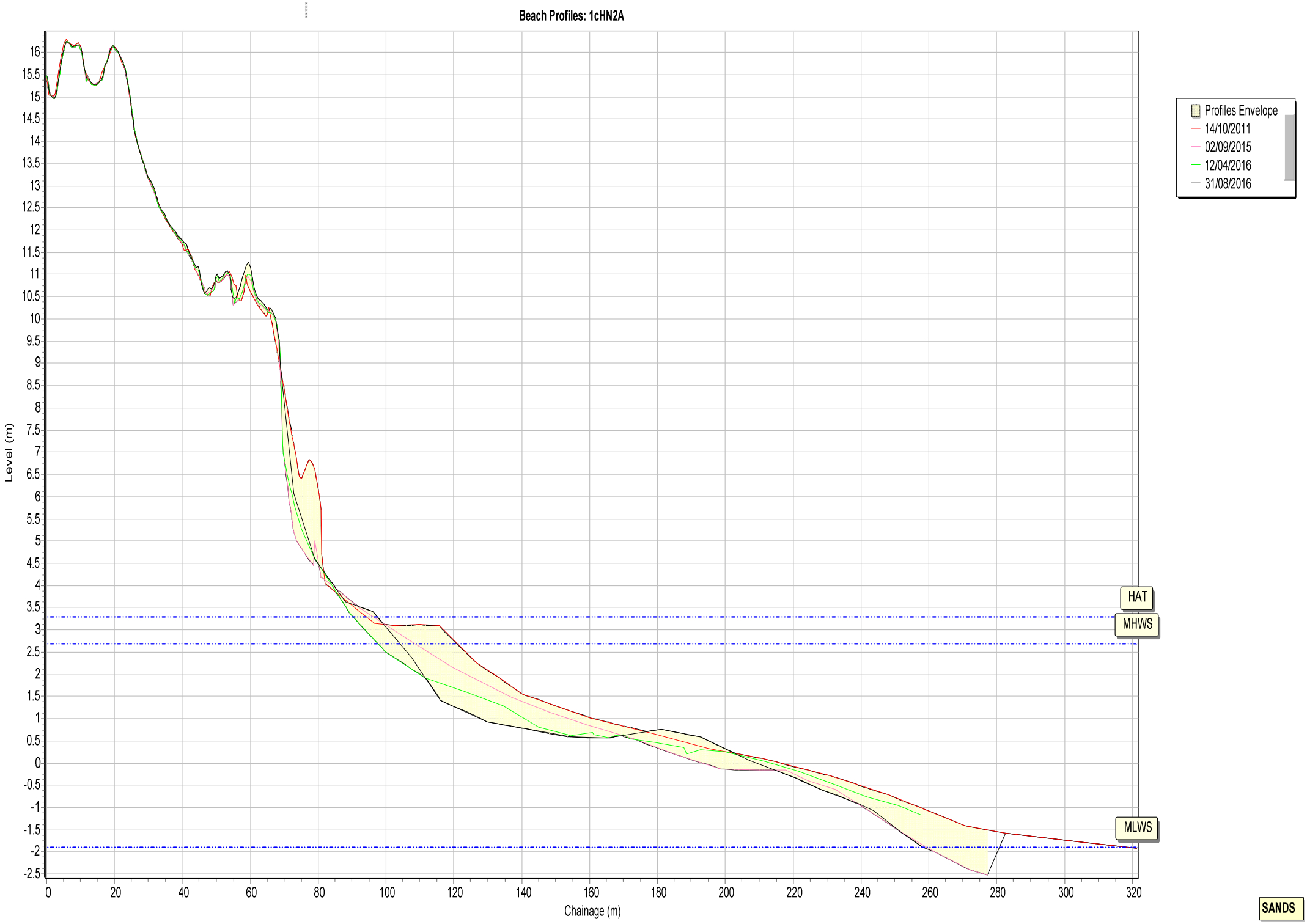
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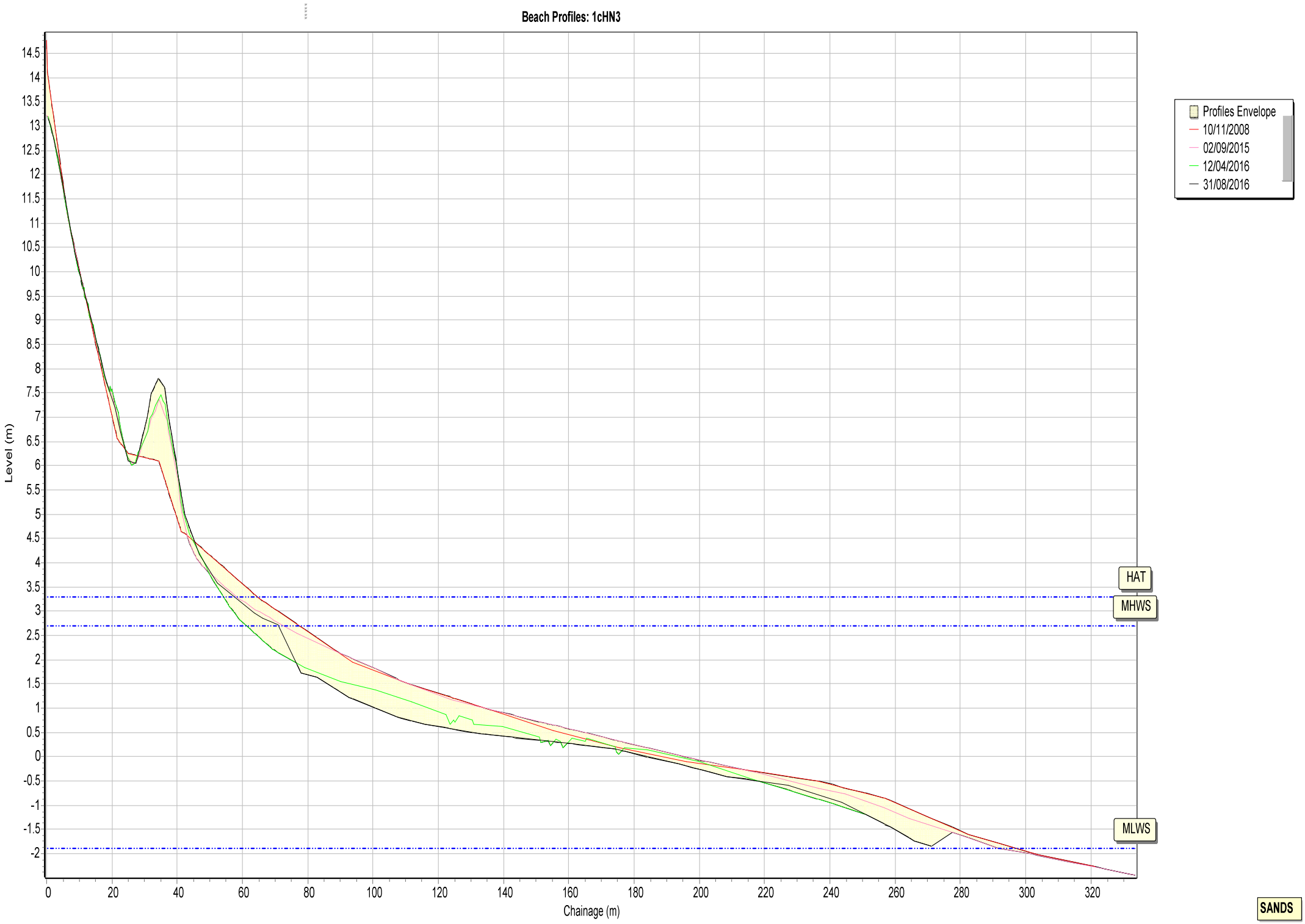
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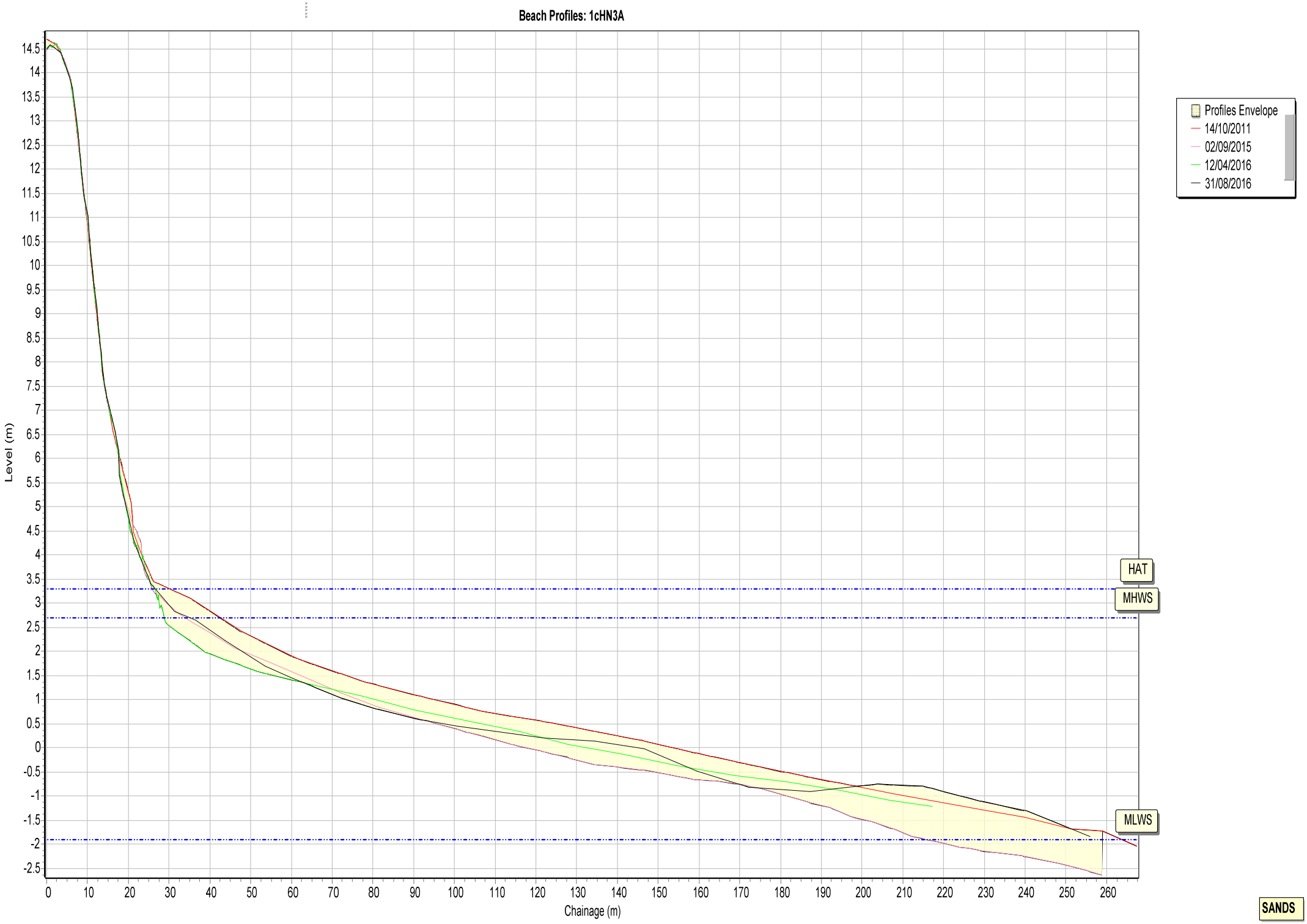
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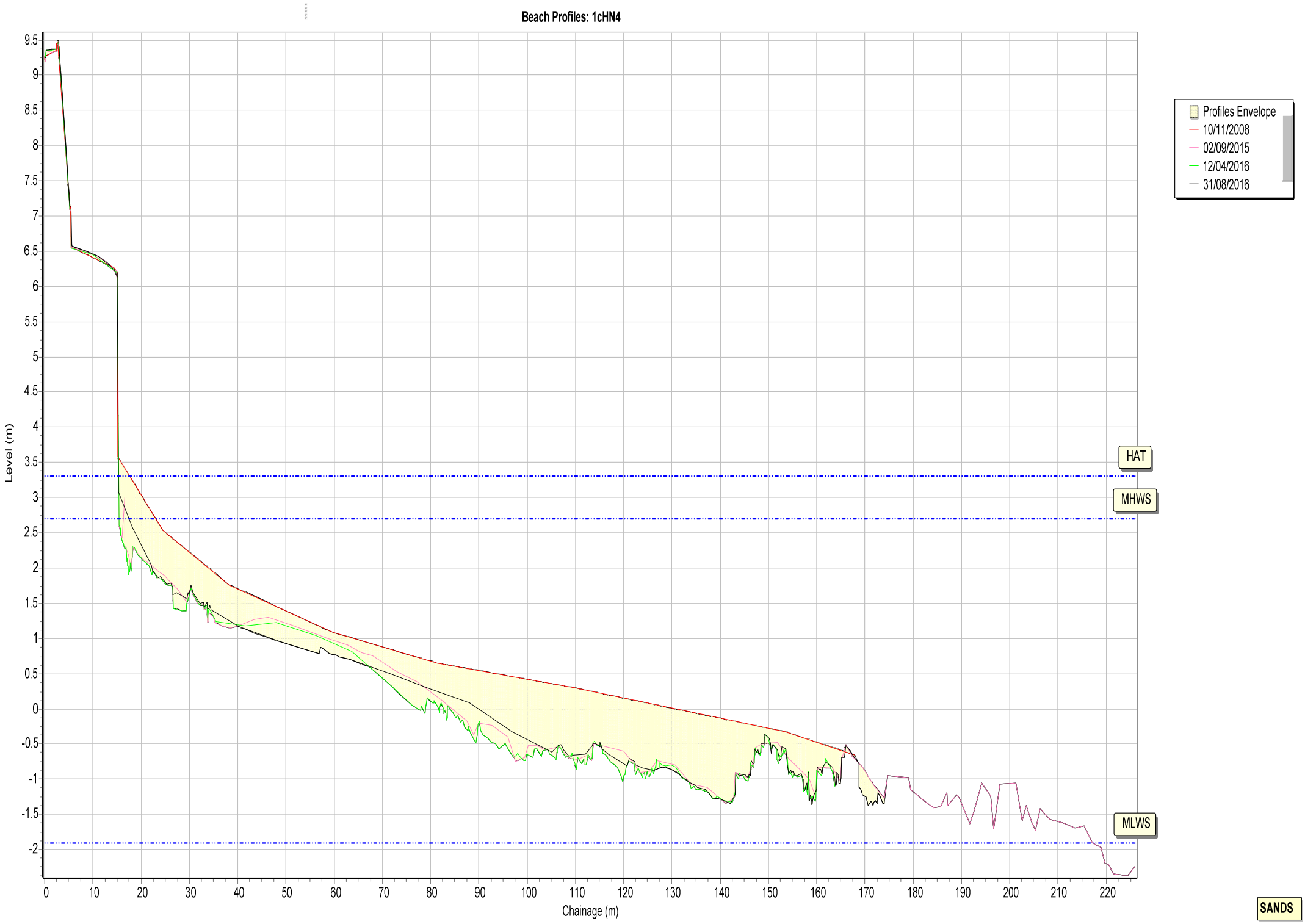
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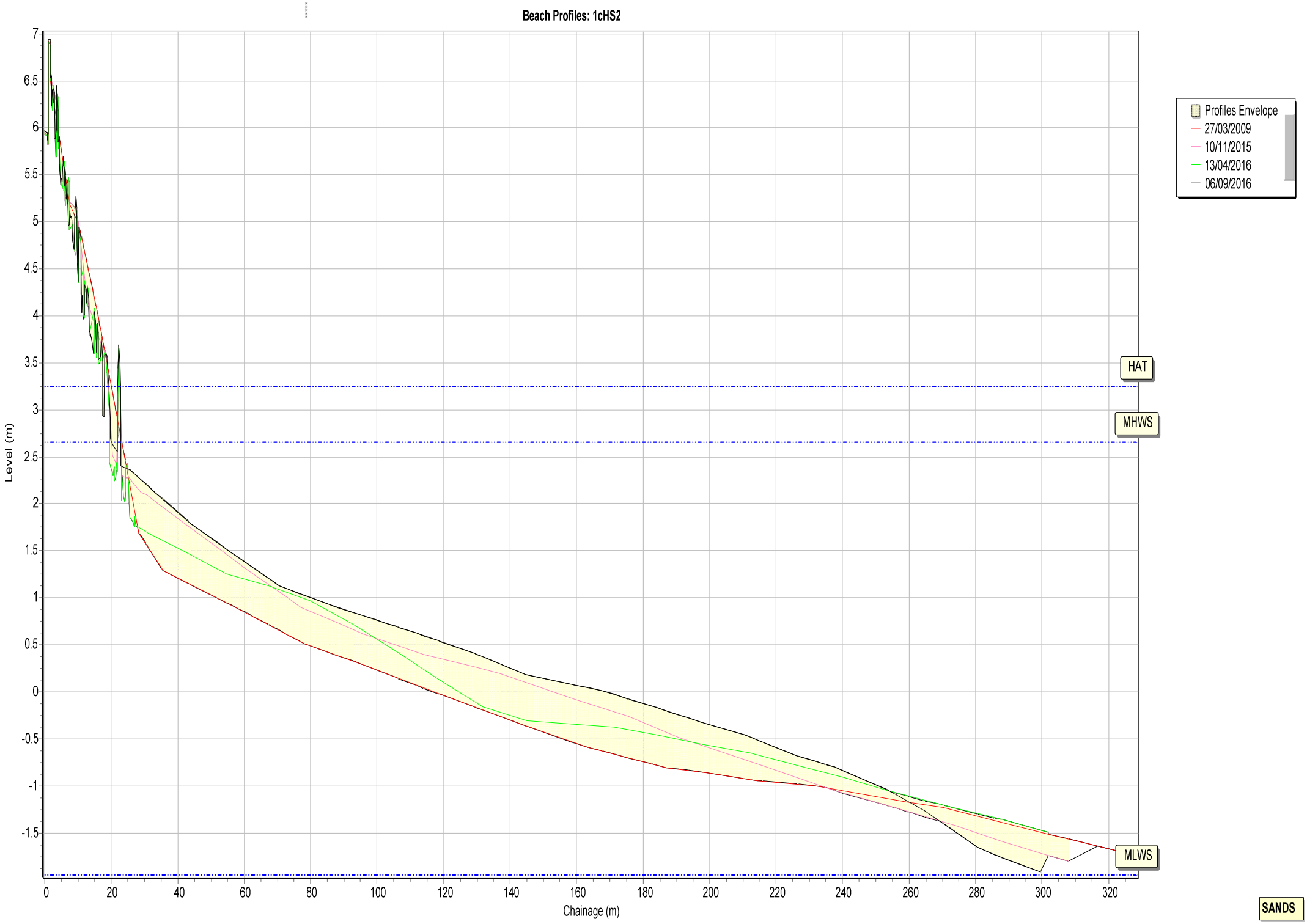
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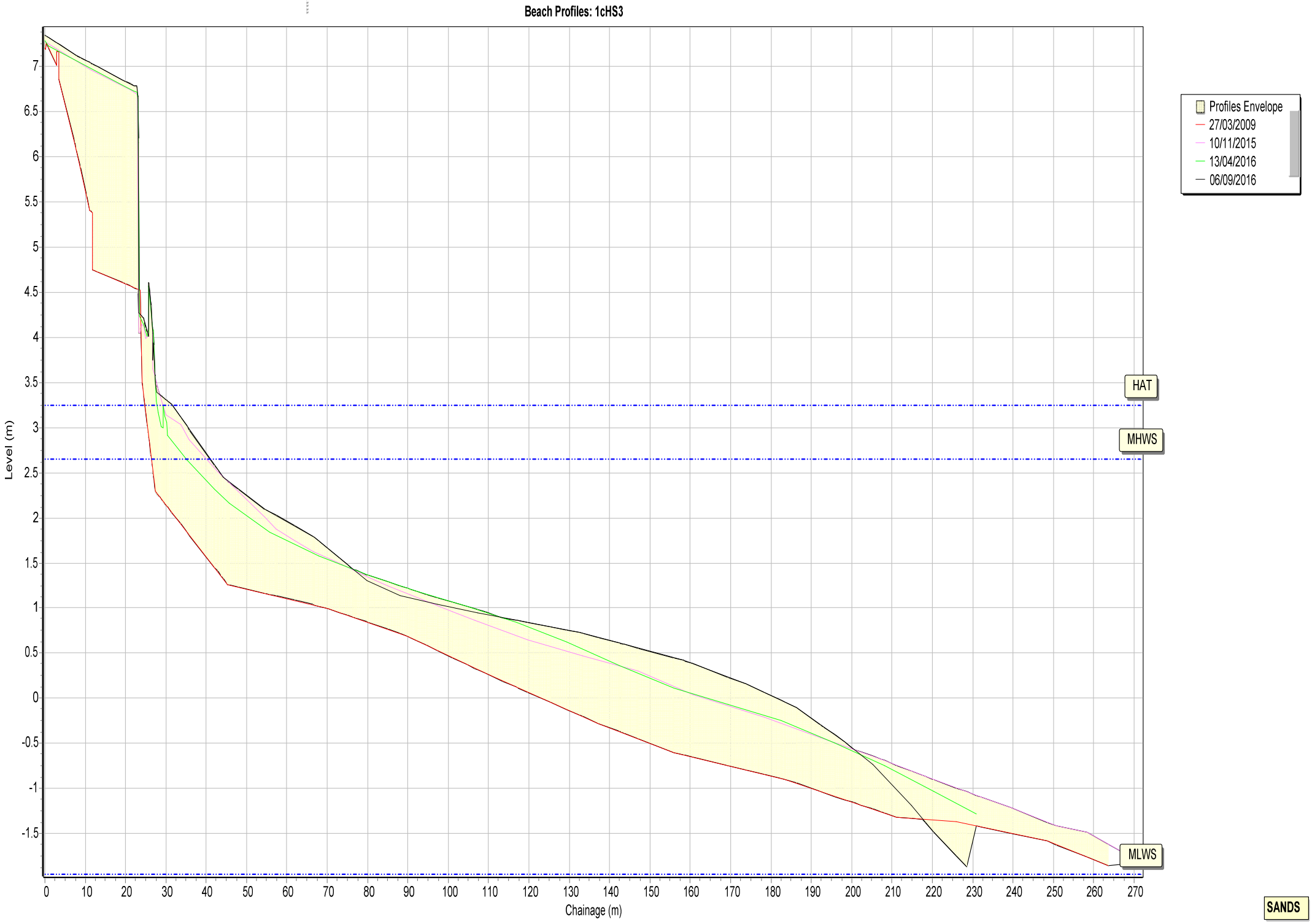
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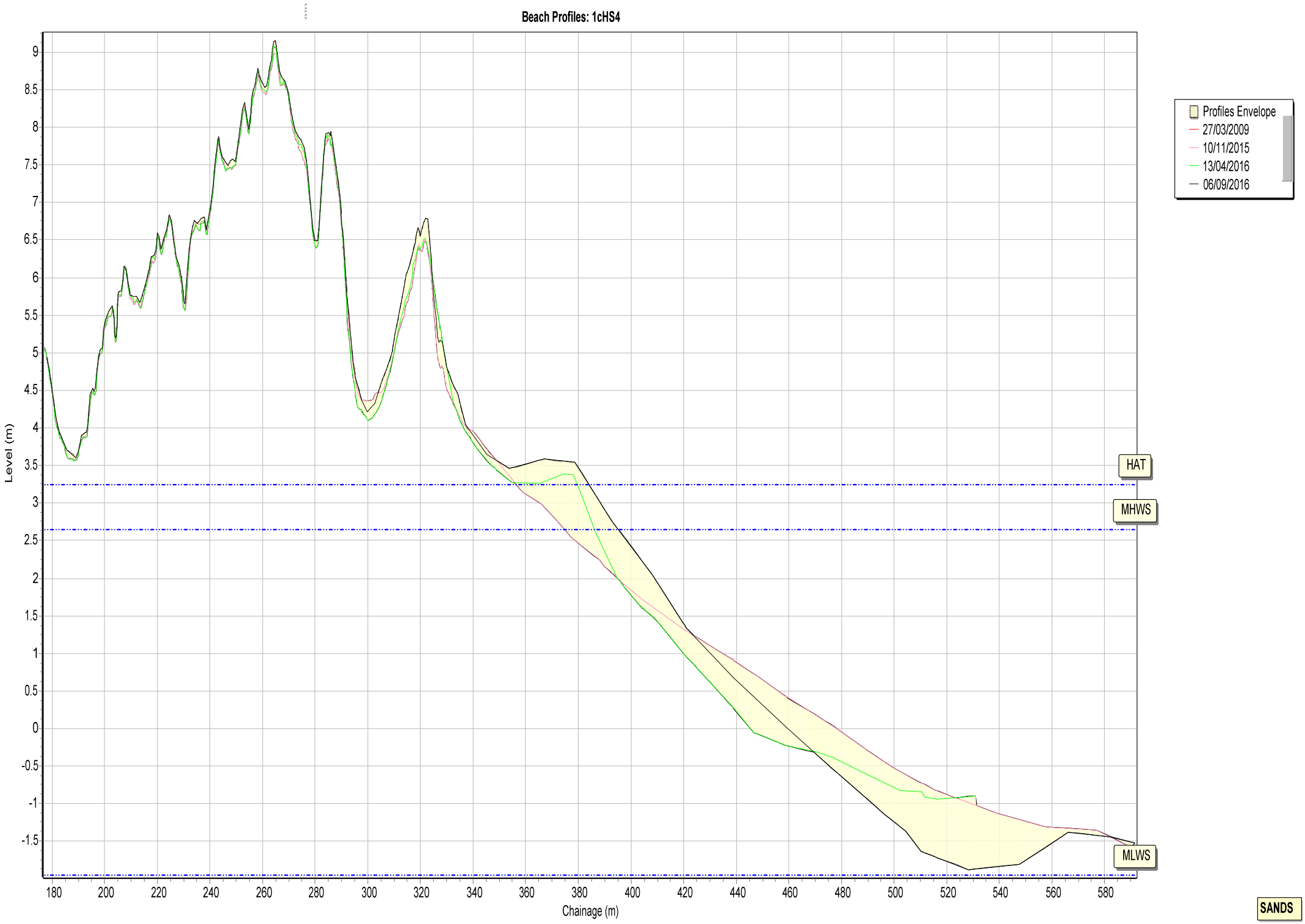
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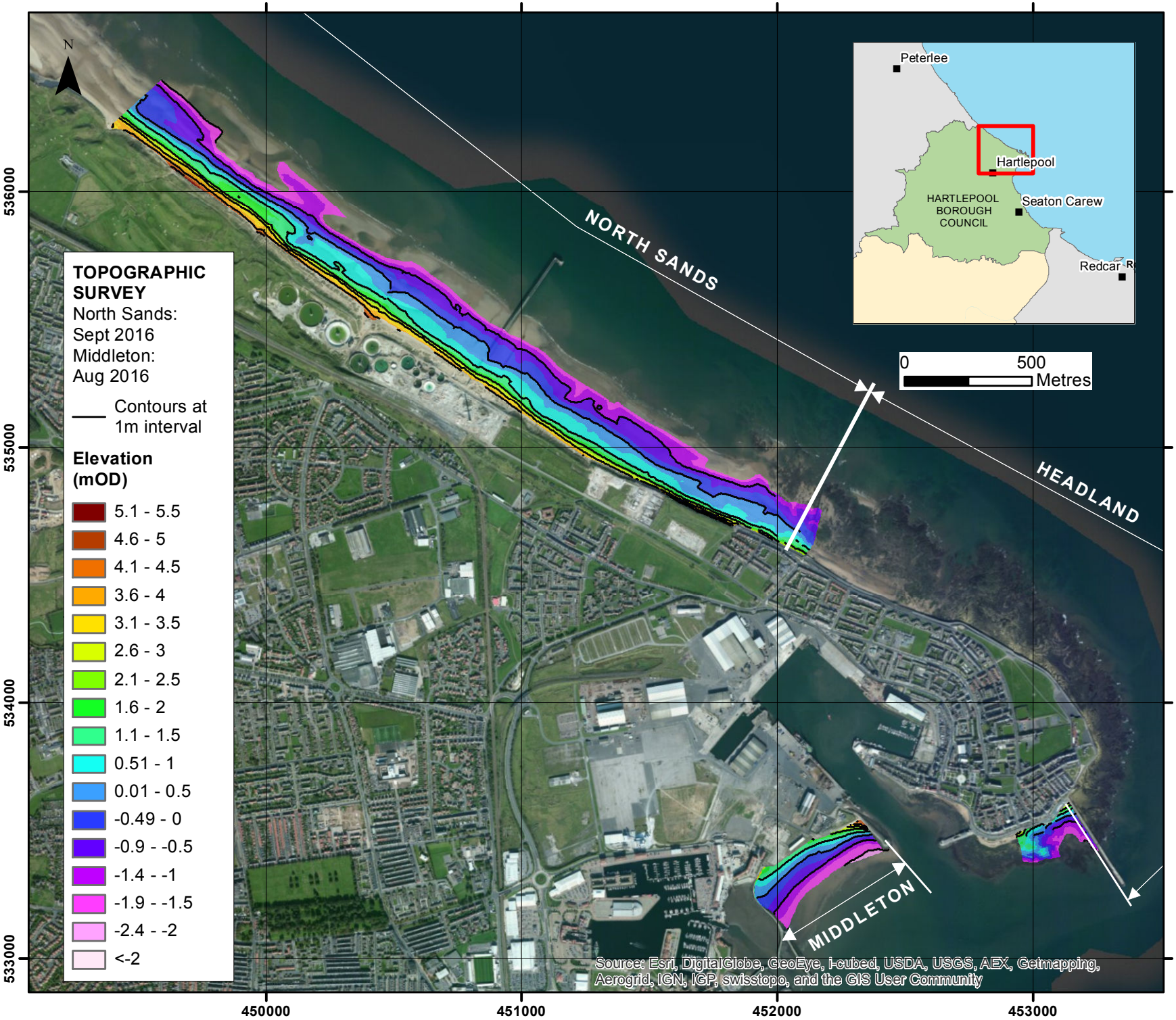
Appendix B

Topographic Survey



Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 1

HARTLEPOOL NORTH

Hartlepool Borough Council Frontage

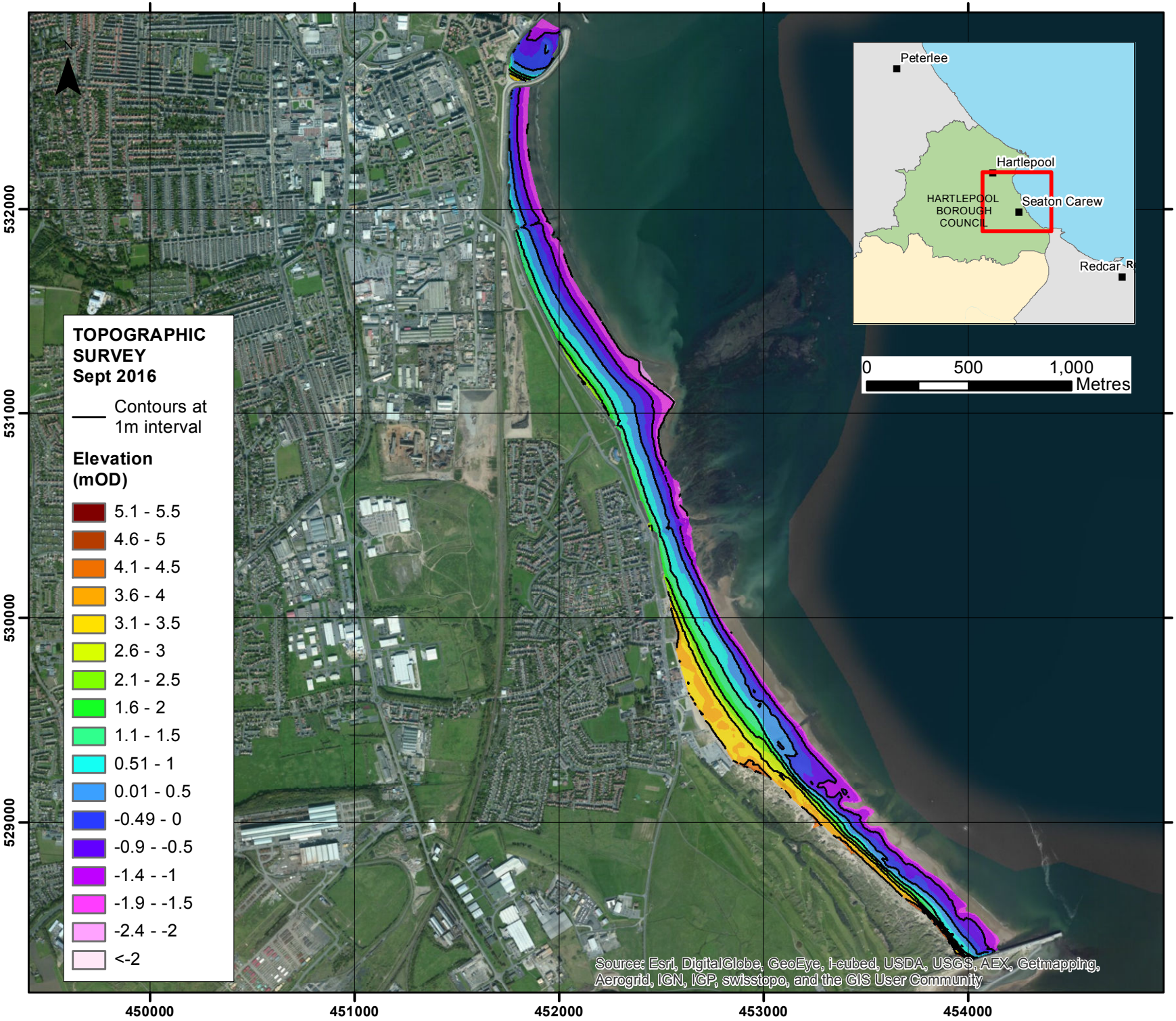
Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:20,000

WATER
Royal HaskoningDHV
Marlborough House
Marlborough Crescent
Newcastle upon Tyne
NE1 4EE

Tel: +44 (0)191 211 1300
Fax: +44 (0)191 211 1313
www.royalhaskoningdhv.com

Royal HaskoningDHV
Enhancing Society Together



Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 2

HARTLEPOOL SOUTH

Hartlepool Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:25,000

WATER
Royal HaskoningDHV
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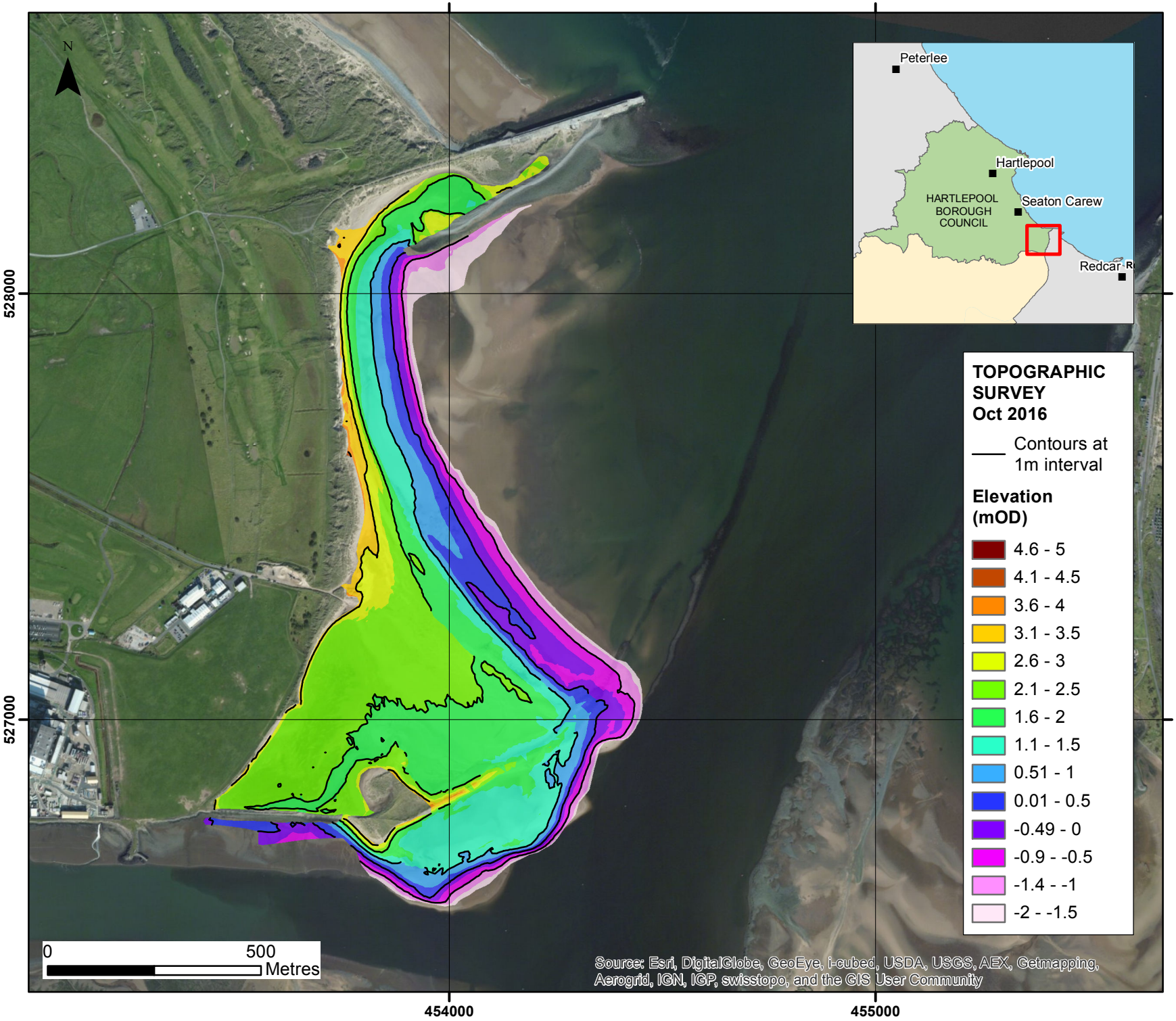
Fax: +44 (0)191 211 1313
www.royalhaskoningdhv.com

Royal HaskoningDHV
Enhancing Society Together



Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 3

HARTLEPOOL NORTH GARE

Hartlepool Borough Council Frontage

Analytical Report 'Full Measures' Survey 2016

Drawing Scale at A4 1:12,000

WATER
Royal HaskoningDHV
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Marlborough Crescent
Newcastle upon Tyne
NE1 4EE

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Fax: +44 (0)191 211 1313
www.royalhaskoningdhv.com

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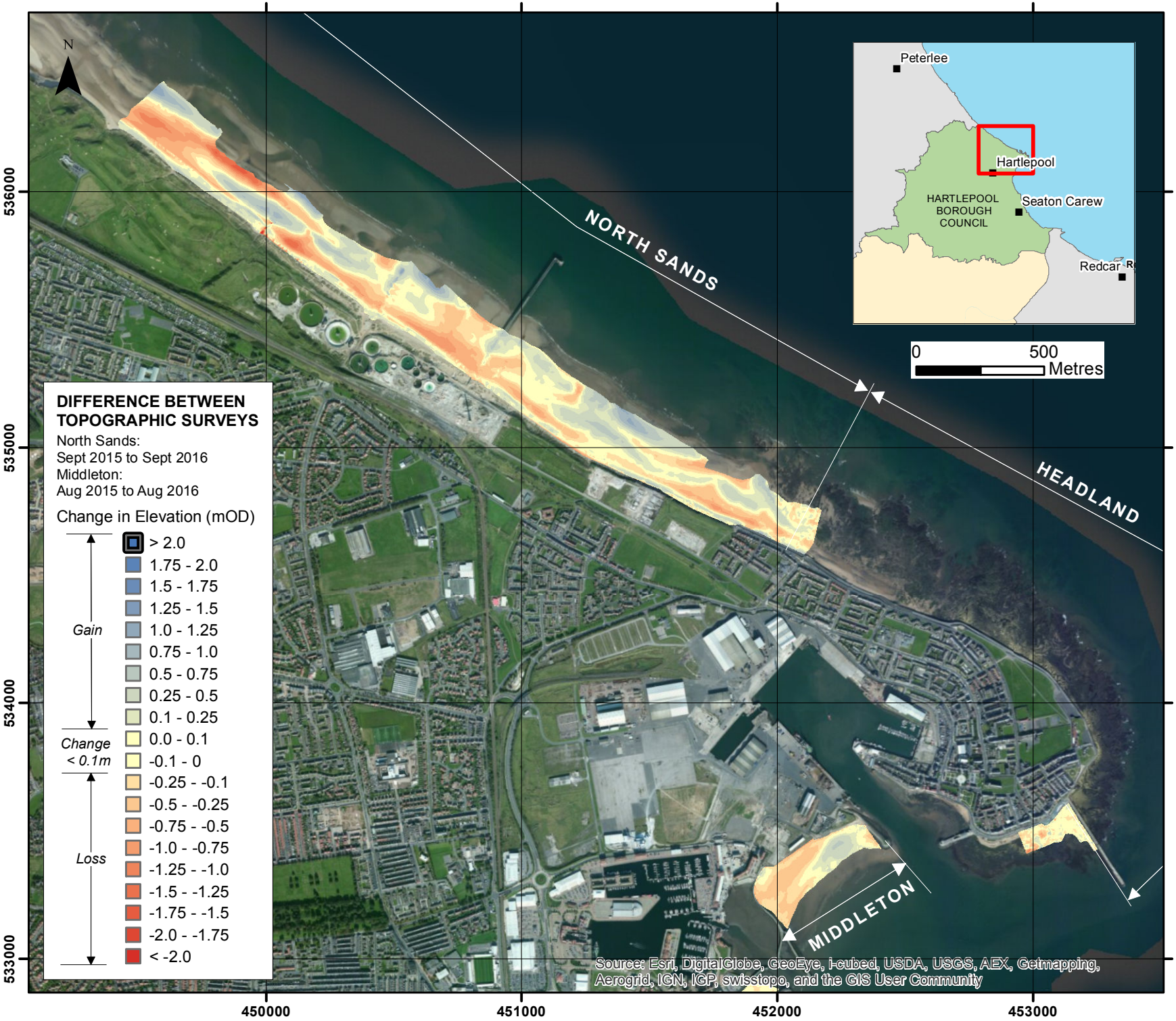

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 3

HARTLEPOOL NORTH

Hartlepool Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:20,000

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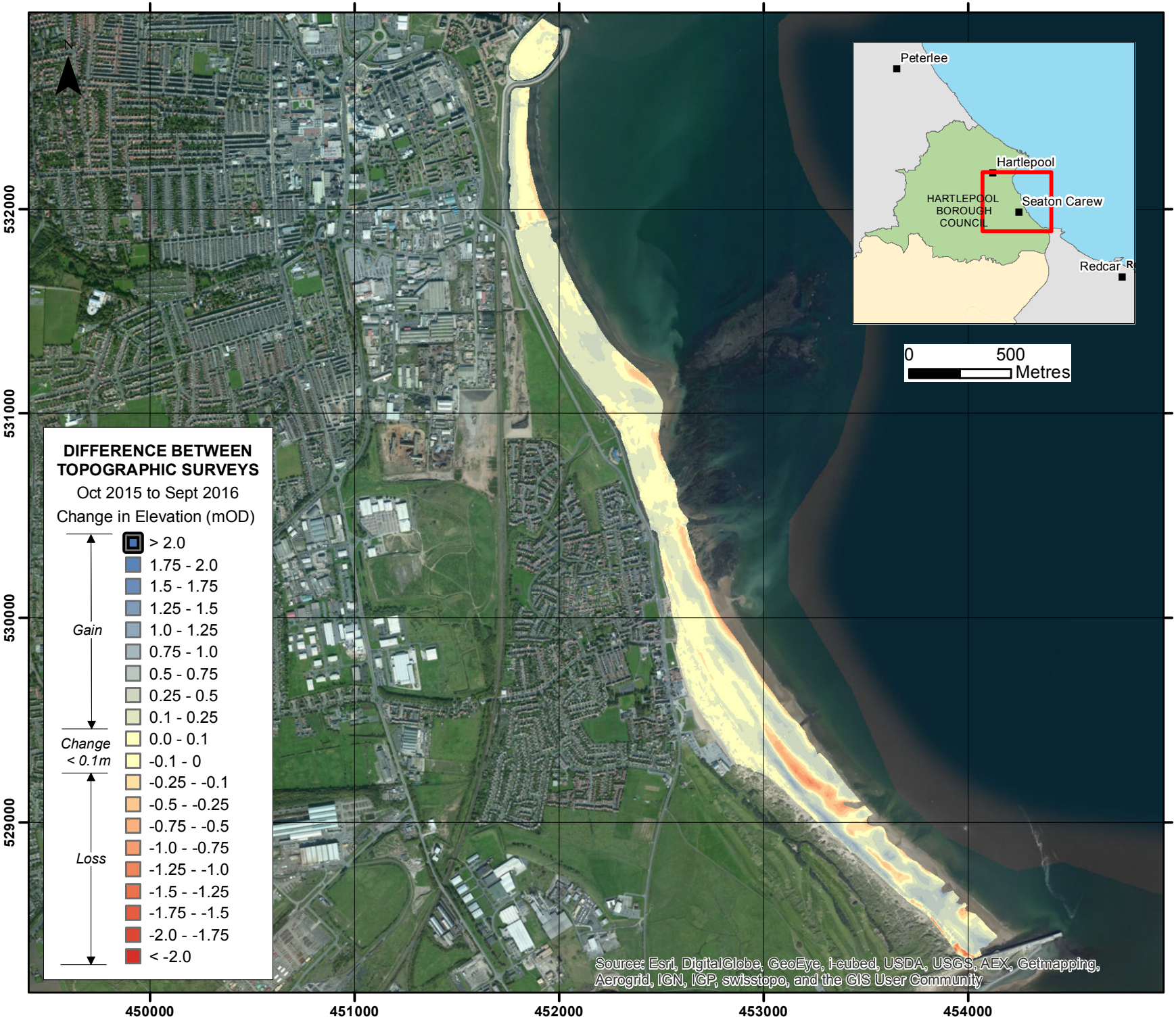

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 4

HARTLEPOOL SOUTH

Hartlepool Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:25,000

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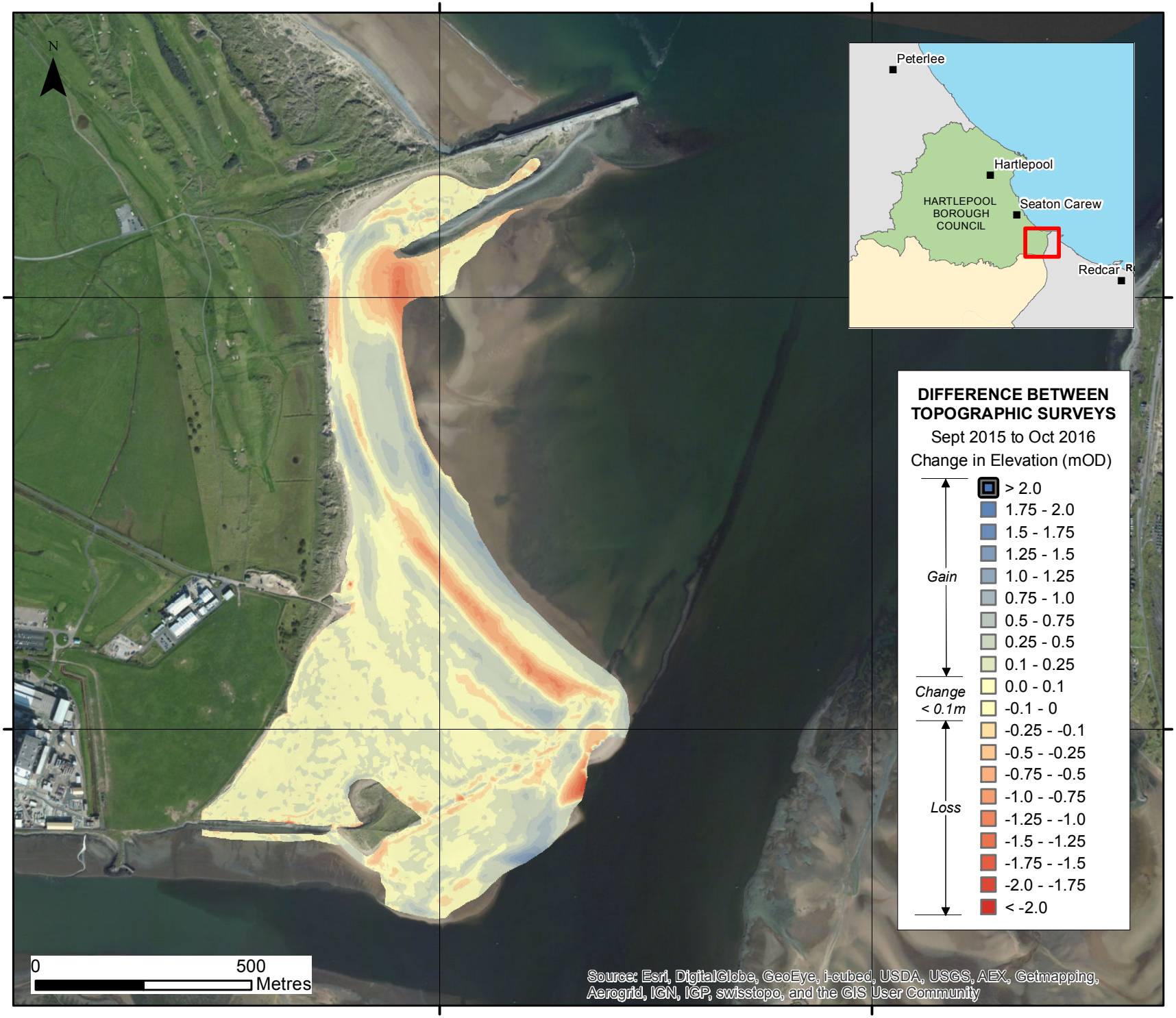

Key

Client: North East Coastal Group

Project: Cell 1 Regional Coastal Monitoring Programme

Appendix B - Map 6

HARTLEPOOL NORTH GARE

Hartlepool Borough Council Frontage

Analytical Report
'Full Measures' Survey 2016

Drawing Scale at A4 1:12,000

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